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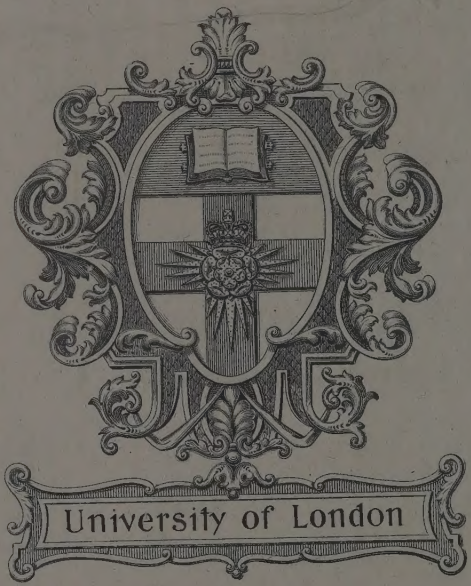
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REPORTS

FROM

COMMISSIONERS, INSPECTORS,

AND OTHERS:

THIRTY-ONE VOLUMES.

—(19.)—

EDUCATION DEPARTMENT

(PHILADELPHIA INTERNATIONAL EXHIBITION)—*continued.*

Session

8 *February*—14 *August* 1877.

VOL. XXXVI.

REPORTS

FROM

COMMISSIONERS, INSPECTORS,

AND OTHERS:

1877.

THIRTY-ONE VOLUMES:—CONTENTS OF THE

NINETEENTH VOLUME.

N.B.—*THE* Figures *at the* beginning of the line, *correspond with the* N° *at the foot of each* Report; *and the* Figures *at the* end of the line, *refer to the* MS. Paging *of the Volumes arranged for The House of Commons.*

EDUCATION DEPARTMENT (PHILADELPHIA INTERNATIONAL EXHIBITION)—*continued*:

[c. 1890.] Education Department: Reports on the Philadelphia International Exhibition of 1876. Vol. III. - - - - - p. 1

HENRY MITCHELL DES & SC.
BOSTON. U.S.A.

INTERNATIONAL EXHIBITION 1876
AWARDED BY
UNITED STATES
CENTENNIAL
COMMISSION
PHILADELPHIA, MDCCCLXXVI

EDUCATION DEPARTMENT.

REPORTS

ON THE

PHILADELPHIA INTERNATIONAL EXHIBITION

OF

1876.

VOL. III.

Presented to both Houses of Parliament by Command of Her Majesty.

LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1878.

[C.–1890.] *Price* 5*s.*

MEMORANDUM.

AS STATED in the Executive Commissioner's Report, Vol. I., page xliii., the medals and diplomas awarded at the Philadelphia Exhibition were uniform, the different degrees of merit being marked by the wording of the Judges' Reports.

The list of successful exhibitors, British and Colonial, was published in the "London Gazette" immediately after the awards were announced; but it is now reproduced as a guide to the recommendations, or Special Reports, on which the Awards were based.

The General Reports of the Judges on those groups which contained Exhibits of special interest to British manufacturers and producers are here given*; but the diagrams, with the references thereto, which, in the case of several Reports, appear in the American text, have not been reprinted, and the contents of this Volume from page 257 to page 880 should therefore be read as extracts only, and not as *complete* Reports.

The Report of the Director of the Bureau of Medical Service at the Philadelphia Exhibition, which will appear in the American Commissioners' Reports, is inserted in this volume, not only on account of its very interesting details, but also with reference to the remarks in Vol. I., page lxix., on the sanitary arrangements of the Exhibition.

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* *The whole Report on "Edge Tools"—which is mainly made up of Mr. MacHardy's remarks—and portions of other Reports, which have been contributed by other British Judges, and are included in Vol. I., form an exception to this rule.*

40609. Wt. 5013.

At page xlvii. of the same Volume the valuable assistance given by the British Judges to the Canadian Commission is mentioned. Since the publication of the Volume in question the thanks of the Government of Canada for these and other services have been received through Her Majesty's Secretary of State for the Colonies, and the correspondence conveying these acknowledgments is therefore included in Vol. III. (*see* page 881).

H. B. S.

31st October, 1878.

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LIST of AWARDS to BRITISH and COLONIAL EXHIBITORS.

BRITISH AWARDS (618).

Name.	Address.	Group.	Awarded for
Adair and Co.	17, Neptune-street, Liverpool	20	Ships' pump.
Addis, J. B., and Sons	Artic Works, Sheffield	15	Carvers' tools.
Ainley, Lord, and Co.	Huddersfield	9	Worsted coatings.
Air Burning Company, Limited	118, Green-street, Glasgow	14	Flat irons.
Aire and Calder Glass Bottle Company, E. Breffit, Proprietor.	83, Upper Thames-street, London	2	Glass bottles, &c.
Aitchison, James	23, Princes-street, Edinburgh	11	Scotch pebble jewellery.
Aked, James, and Son	Halifax	9	Worsted coatings.
Allen, Frederick, and Sons	Canal-road, Mile End-road, London	3	Sugar bonbons, &c.
Allen and Hanburys	Plough-court, Lombard-street, London	3	Cod liver oil.
Andrew, J. E. H.	Waterloo-road, Stockport	4	Tobacco machinery.
Andrews, H., and Co.	29, Albion-street, Leeds	9	Coatings.
Appleby Brothers	Emerson-street, Southwark, London	20	Cranes.
Ash and Lacy	Meriden-street, Birmingham	1	Tinned iron and zinc plates.
Ashworth and Sons	Egerton Mills, Bolton	8	Threads and yarns.
Arter, George	West of England Anatto Works, Bishop's Sutton, Bristol.	4	Preserved rennets.
Arter, George	Bristol	4	Anatto colouring for cheese and butter.
Atkinson, J. and E.	24, Old Bond-street, London	3	Perfumery, &c.
Audsley and Bowes	11, Dale-street, Liverpool	27 & 28	Work in folio—"Keramic Art in Japan."
Augener, George, and Co.	86, Newgate-street, London	28	Pauer's musical classics.
Aveling and Porter	Rochester	18	Traction engine.
Aveling and Porter	Rochester	23	Steam traction road roller.

Name.	Address.	Group.	Awarded for
Bailey, W. and J. A.	Alloa, Scotland	2	Rockingham earthenware.
Baird, W., and Co.	Gartsherrie Ironworks, Coatbridge, N.B.	1	Coal cutting machine.
Baker, C., and Sons	98, Lichfield-street, Birmingham	15	Coffin trimmings, &c.
Baker, William	96, Pembroke-street, Bingfield-street, Caledonian road, London.	15	Turn screws, &c.
Ball, James	12, Duke-street, Grosvenor-square, London	4	Sauce, &c.
Barlow and Jones (Limited)	2, Portland-street, Manchester	8	Vestings, quilts, &c.
Barnard, B.	107, St. Paul's-road, Highbury, London	7	Furniture.
Barnard, Bishop, and Barnards	Norfolk Ironworks, Norwich	27	Artistic castings, &c.
Barnard, Bishop, and Barnards	Norfolk Ironworks, Norwich	8	Wire netting.
Barnard, Bishop, and Barnards	Norfolk Ironworks, Norwich	23	Garden furniture.
Bartholomew, John	Chambers-street, Edinburgh	26 & 28	Maps.
Bates, Walker, and Co.	Dale Hall Works, Burslem	2	Earthenware.
Bauer, Gilbert L.	49, Tottenham-street, Tottenham Court-road, London.	25	Harmonium.
Beck, R. and J.	31, Cornhill, London	25	Microscopes.
Bedford, William	326, Camden-road, London	27	Photographs.
Beesley and Sons	Abbey-road Boiler Works, Barrow-in-Furness	21	Punching and shearing machine.
Bennett, T., and Son	70, Turnmill-street, Farringdon-road, London	3	Goldbeater's skin.
Bessbrook Granite Works	Bessbrook, Ireland	1	Granite monuments.
Besson, F., & Co.	198, Euston-road, London	25	Brass musical instruments.
Bewley and Draper	23, Mary-street, Dublin	24	Ginger ale and lithia water.
Bickford, Smith, and Co.	Tuckingmill, Cornwall	16	Safety fuses for blasting.
Bindley and Co.	The Brewery, Burton-on-Trent	4	Ale.
Birchall, J. D., and Co.	Wellington and Burley Mills, Leeds	9	Tweeds.
Blackwood, John, and Co.	18, Bread-street-hill, London	3	Inks.
Bliss, W., and Sons	Chipping Norton, Oxfordshire	9	Woollens.

Name.	Address.	Group.	Awarded for
Bond, John, daughter of late, now Mrs. Hickisson.	15, Southgate-road, London	3	Marking ink.
Boosey and Co.	295, Regent-street, London	25	Brass musical instruments.
Boulinikon Floor Cloth Manufacturing Company, Limited.	Worsley-street, Salford, Manchester	8	Floor cloth.
Bowes, John L., and Brother	11, Dale-street, Liverpool	9	Wools and mohair.
Bowman, Charles	6, King-street, Tower Hill, London	3	Inks.
Bradbury, Agnew, and Co.	Bouverie-street, London	28	Books and specimens of engravings.
Brearley, Robert, and Son	Batley	9	Beavers and pilots.
Brierley, Sons, and Reynolds	81A, Edgware-road, Hyde Park, London	18	Railway signals.
Brinsmead, J., and Sons	18, Wigmore-street, London	25	Pianos.
British and Foreign Bible Society	London	28	Translations of the Bible.
British and Foreign Blind Association	33, Cambridge-square, Hyde Park, London	28	Writing frames, books, &c. for the blind.
British Government	—	—	Collective Exhibit.
Brooke, Edward, and Sons	Field House Fire Clay Works, Huddersfield	2	Sanitary tubes.
Brookes and Crookes	Atlantic Works, St. Philip's-road, Sheffield	15	Pocket knives, razors, &c.
Brook, Jonas, and Brothers	Meltham Mills, Huddersfield	8	Sewing cotton.
Brooks and Cooper	Mousehole Forge, Sheffield	21	Anvils.
Brown-Westhead, T. C., Moore, and Co.	Cauldon-place, Staffordshire Potteries	2	Porcelain and earthenware.
Brown, J. S., and Sons	Bedford-street, Belfast	8	Linen fabrics.
Brown, J. B., and Co.	90, Cannon-street, London	8	Galvanized wire netting.
Brown, John, and Co. (Limited)	Atlas Works, Sheffield	1	Armour plates.
Brownfield, W., and Son	Cobridge, Staffordshire	2	Porcelain and earthenware.
Brunner, Mond, and Co.	Winnington, Northwich, Cheshire	3	Chemicals.
Bryant and May	Fairfield Works, Bow, London	3	Matches.
Buchanan, James	56 to 62, Dale-street, Tradeston, Glasgow	5	Fish-hooks.
Buckley, J., and Co.	Moorcroft Mills, Delph, near Manchester	9	Cotton and woollen shawls.
Buckley, J. E. and G. F.	Linfitts Mill, Delph, near Manchester	9	Shawls.
Bullivant, Thomas	104, Ledbury-road, Bayswater, London	6	Sash windows.

Name.	Address.	Group.	Awarded for
Bull, William, F.L.S.	King's Road, Chelsea, London	29	Coloured plates of flowers.
Burnand, J., and Co.	Leicester Works, Leicester-street, Sheffield	15	Fine cutlery, &c.
Calvert, F. C., and Co.	Bradford, near Manchester	3	Carbolic acid.
Calverley, Titus, and Sons	Huddersfield	9	Doeskins, &c.
Cameron, Mrs. Julia M.	Care of Mrs. C. H. Cameron, Freshwater, Isle of Wight.	27	Photographs.
Cammell, Charles, and Co., Limited	Cyclops Works, Sheffield	1	Armour plates.
Campbell, Hugh, and Son	Newry Granite Polishing Works, Moor Quarries, Newry, Ireland.	1	Wrought granite.
Carr, Isaac, and Co.	Twerton Mills, Bath	9	Meltons and beavers.
Cassell, Petter, and Galpin	La Belle Sauvage-yard, Ludgate-hill, London	28	Illustrated books.
Cassell, Petter, and Galpin	La Belle Sauvage-yard, Ludgate-hill, London	27	Lithographs, &c.
Chance Brothers and Co.	Glass Works, near Birmingham	25	Optical glass.
Chance Brothers and Co.	Glass Works, near Birmingham	2	Glass discs for optical purposes.
Chance Brothers and Co.	Glass Works, near Birmingham	3	Chemical products.
Chatwood, Samuel	120, Cannon-street, London	15	Fire and burglar proof safes.
Cheavin, George	Wide Bargate Filter Works, Boston, Lincolnshire.	14	Water filter.
Child, William	Huddersfield	9	Mohair and sealskins.
Clark, Captain E. Podmore	Edward-street, Bath	16	Military models for illustrating teaching drill movements.
Clark, John, jun., and Co.	16, George-street, Mile End, Glasgow	8	Sewing cotton.
Clark, Latimer, Standfield, and Co.	6, Westminster-chambers, Victoria-street, London.	19	Model of gridiron stages.
Clegg, Jesse	Huddersfield	9	Cotton warp.
Coats, J. and	Ferguslie Thread Works, Paisley	8	Sewing cotton.
Codd, Hiram	50, Grove-lane, Camberwell, London	20	Patent globe stoppered soda water bottles.

Name.	Address.	Group.	Awarded for
Collier, Luke	Wellington Works, River-street, Rochdale	3	Confectioners' machine tools.
Collinson and Lock	109, Fleet-street, London	7	Furniture.
Collmann, Leonard W.	67, George-street, Portman Square, London	7	Furniture.
Committee of Council on Education	South Kensington, London	—	Contributions from South Kensington Museum.
Cooper and Holt	48, 49, and 50, Bunhill-row, London	7	Furniture.
Corbett, J., M.P.	Stoke Prior Salt Works, Worcestershire	3	Refined Worcestershire salt.
Cork Distilleries Company	Cork, Ireland	4	Whiskey.
Corry, W., and Co.	Cromac Springs, Cromac-street, Belfast	24	Aërated medicinal waters.
Cox Brothers	Camperdown Works, Lochee, Dundee	8	Jute cords, &c.
Cox and Sons	28, 29, and 31, Southampton-street, Strand, London.	7	Furniture.
Cox and Sons	28, 29, and 31, Southampton-street, Strand, London.	27	Forged metal work, stained glass, &c.
Craig and Rose	Caledonian Oil and Colour Works, Edinburgh	3	Colours.
Crook, Graham, and Co.	Premier Boiler Works, Halifax	—	Sanitary tubes—firebrick clay for furnaces.
Crosby, Lockwood, and Co.	7, Stationers' Hall-court, Ludgate-hill, London.	28	Scientific books.
Crosse and Blackwell	Soho-square, London	4	Pickles, sauces, &c.
Crosse and Blackwell	Soho-square, London	4	Preserved fruit.
Crosse and Blackwell	Soho-square, London	3	Vinegar.
Crosse and Blackwell	Soho-square, London	5	Salmon.
Crossley, J., and Sons, Limited	Deanclough Mills, Halifax	9	Carpets.
Crouch, Henry	66, Barbican, London	25	Microscopes.
Crown Perfumery Company	40, Strand, London	10	Combs.
Crown Perfumery Company	40, Strand, London	3	Perfumes, &c.
Cwmorthin Slate Company, Limited	Port Madoc, North Wales	1	Roofing slates.

Name.	Address.	Group.	Awarded for
Dallmeyer, J. H.	19, Bloomsbury-street, London	25	Microscopes and photographic lenses.
Daniell, A. B., and Son	46, Wigmore-street, London	2	Porcelain and pottery.
Dashwood, C. W.	St. Clement's-churchyard, Strand	27	Original designs for oil cloth.
Davey, Paxman, and Co.	Colchester, Essex	20	Portable steam engine, &c.
Davies, Robert S., and Sons	Stonehouse Mills, Gloucestershire	9	Cloths, beavers, &c.
Davis and Wilson	Sun-street West, Birmingham	17	Whips, canes, &c.
Davis and Wilson	Sun-street West, Birmingham	10	Mountings for whips, &c.
Day, John, and Son	Huddersfield	9	Cheviot coatings.
Debenham and Freebody	27, 29, and 31, Wigmore-street, London	10	Gloves.
Dell, Captain William	Great Bentley, Colchester	4	Wheat.
Dennis, T. H. P., and Co.	Anchor Ironworks, Chelmsford	20	Patent full-weigh high pressure valves.
Dent, M. F.	33, Cockspur-street, Charing Cross, London	25	Chronometers and watches.
Desoto Alkali Company, Limited	Widnes, Lancashire	3	Caustic soda.
Dewhurst, John, and Sons	Belle Vue Mills, Skipton	8	Sewing cotton.
Dicksons, Ferguson, and Co.	Linen Hall-street, Belfast	8	Linen fabrics.
Doulton and Co.	High-street, Lambeth, London	14	Plumbago crucibles.
Doulton, Henry, and Co.	63, High-street, Lambeth, London	2	Terra cotta and stoneware.
Doulton, Henry, and Co.	63, High-street, Lambeth, London	29	Terra cotta ware.
Doulton and Watts	Lambeth Pottery, Lambeth, London	2	Stone ware, "Doulton" vases.
Doulton and Watts	Lambeth Pottery, Lambeth, London	7	Mantelpiece.
Dunbar, McMaster, and Co.	Gilford, County Down, Ireland	8	Bleached and dyed linen threads.
Dunn, Robert, and Co.	Oak Villa, St. Austell, Cornwall	1	Clays.
Dunraven, the Countess of	Adare, co. Limerick, Ireland	10	Needlework.
Edge and Sons	Coalport Works, Shifnal, Shropshire	26	Wire ropes, chains for engineering mining purposes.

Name.	Address.	Group.	Awarded for
Edinburgh Western Tanning, Currying, and Japanning Company, Limited.	135, West Port, Edinburgh	12	Leather.
Edwards, John	King-street, Fenton, Staffordshire	2	White earthenware.
Eley Brothers (Limited)	254, Gray's-Inn-road, London	16	Wadding, shells, caps, &c.
Elkington and Co.	Newhall-street, Birmingham	27	Inlaid work in metal.
Elkington and Co.	Newhall-street, Birmingham	11	Enamelled work.
Elkington and Co.	Newhall-street, Birmingham	11	Artistic metal work.
Elkington and Co.	Newhall-street, Birmingham	11	Electro-plated ware.
Elkington and Co.	Newhall-street, Birmingham	27	Bas reliefs in metal, &c.
Elrick, C. G.	Aldermanbury-postern, London	10	Horn combs.
Engert, A. C., and C.	75, City-road, London	7	Gilt mouldings.
English, John, and Co.	Feckenham, near Redditch	10	Needles and steel-pens.
Etzensberger, R. U.	Midland Hotel, St. Pancras, London	14	Tea and coffee apparatus.
Evans, David	Studley, Redditch	10	Needles.
Evans and Stafford	Campbell-street, Leicester	4	Cheese.
Fairbairn, Kennedy, and Naylor	Leeds	8	Machine for spinning jute.
Fairbairn, Kennedy, and Naylor	Leeds	21	Quadruple drilling-machine.
Feetham, M., and Co.	9, Clifford-street, London	27	Artistic castings.
Feetham, M., and Co.	9, Clifford-street, London	14	Grates and fire-places.
Fenton, Connor, and Co.	Linen Hall, Belfast	8	Linen fabrics.
Fenton, J.	74, Great Hampton-street, Birmingham	10	Pearl buttons.
Ferguson Brothers	Holme Head Works, near Carlisle	8	Dyed Silesias.
Festa, G. P.	Charles-street, Grosvenor-square, London	10	Corsets.
Field, J. C. and J.	Lambeth Marsh, London	3	Candles, soap, &c.
Field, William	Liverpool	4	Oatmeal.
Fison, J. P.	Feversham Works, Cambridge	23	Safety-guard for drum-cylinder.

Name.	Address.	Group.	Awarded for
Firmin and Sons	153, Strand, London	10 & 16	Military and naval buttons, Swords (two medals).
Fletcher, Robert, and Sons	Paper Works, Stoneclough, near Manchester	13	Tissue Paper.
Francis and Co.	Cliffe Creek, Rochester, and Bridge-foot, Vauxhall, London.	2	Portland and Parian cement, and articles manufactured.
French and Co.	St. Mary's Mills, Norwich	9	Crape.
Frodsham, C., and Co.	84, Strand, London	25	Watches and clocks.
Fry, J. S., and Co.	252, City-road, London	4	Chocolate.
Fryer, C. E.	London	5	Pilchards in oil, preserved by Cornish Sardine Co., Falmouth.
Fussell, James, Sons and Co.	Frome, Somerset	23	Scythe blades, &c.
Gadd, Thomas	Salford, Manchester	8	Calico printing machine, &c.
Gadd, Thomas	Salford, Manchester	21	Top pressure engraving machine.
Galloway, W. and J., and Sons	Knott Mill Iron Works, Manchester	20	Steel boilers.
Gardner, J., and Sons	453, Strand, London	14	Lamps and candlesticks.
Gaskell, Deacon, and Co.	Widnes, Lancashire	3	Chemicals.
Geological Survey of United Kingdom, A. C. Ramsay, LL.D., F.R.S., Director-General.	28, Jermyn-street, London	1 & 28	Maps.
Gerrard, A. W.	153, Liverpool-road, London	3	Chemicals.
Gerrard, A. W.	153, Liverpool-road, London	24	Mustard plasters, &c.
Geyelin and Co.	Belgrave House, Argyle-square, London	4	Concentrated food.
Gibbs, G.	29, Corn-street, Bristol	16	Metford patent rifle.
Gibson, William	Castle-place, Belfast	11	Jewellery.
Gimson and Coltman	Duke-street, Leicester	22	Knitting machine.
Goggin, Jeremiah	74, Grafton-street, Dublin	11	Bog oak jewellery, &c.
Good, Frank M.	Minories, London	27	Views of Palestine.

Name.	Address.	Group.	Awarded for
Goodall, Backhouse, and Co.	Boar-lane, Leeds	4	"Yorkshire Relish."
Goodall, C., and Son	24, Great College-street, Camden Town, London.	13	Playing cards.
Governor and Company of Copper Miners in England.	Cwm Avon Works, Taibach, Glamorganshire	1	Tin plates.
"Graphic," The Proprietors of the	190, Strand, London	28	Illustrated newspaper.
Gratz, G. F.	Constitution Hill, Birmingham	13	Dating stamp.
Grays Chalk Quarries Company, Limited	90, Lower Thames-street, London	1	Chalk and chalk flint.
Great North of Scotland Granite Company, Limited.	Peterhead, N.B.	1	Pedestal and base of red granite.
Greenbank Alkali Company	St. Helen's, Lancashire	3	Chemicals.
Green, E., and Son	Economiser Works, Wakefield	20	Fuel economiser for heating the feed water for steam boilers.
Green, J., and Nephew	107, Queen Victoria-street, London	2	Glass ware, &c.
Green, J., and Nephew	107, Queen Victoria-street, London	14	Chandeliers and candelabra.
Green, John	12, Graham-terrace, Ridley-road, Kingsland, London.	3	Gelatine, &c.
Greening, N., and Sons	Warrington	8	Woven wire.
Greenmount Spinning Company	Greenmount Factory, Harold's Cross, Dublin	8	Linen fabrics.
Greenwood and Batley	Albion Works, Leeds	13	Job printing press.
Greenwood and Batley	Albion Works, Leeds	12	Sewing machine for leather.
Greenwood and Batley	Albion Works, Leeds	21	Bolt heading machine.
Greenwood and Batley	Albion Works, Leeds	8 & 9	Tying machine for looms.
Gwynne and Co.	Essex-street Works, Strand, London	20	Pump engines, gas exhauster.
Gwynne, J. and H.	Hammersmith, London	20	Compound surface condensing engine.
Hall, Thomas	8, George-street, Edinburgh	8	Hand painted cloths.

Name.	Address.	Group.	Awarded for
Harding, C. and E.	Islington Lodge, Lynn	10	Needlework.
Hardman, John, and Co.	Newhall-hill, Birmingham	27	Stained glass, &c.
Hardy Patent Pick Company	Mining Tool Works, Eccleshall-road, Sheffield.	1	Patent picks.
Hargreave and Nusseys	Farnley Low Mills, Leeds	9	Worcester coatings.
Harper and Moores	Stourbridge	2	Fire brick.
Harrison, George King	The Lye and Brettell Works, Stourbridge	1	Fire clays.
Harrison, George King	The Lye and Brettel Works, Stourbridge	2	Fire bricks, pot clay, &c.
Hart, Son, Peard, and Co.	Wych-street, Strand, London	7	Furniture.
Hart, Son, Peard, and Co.	Wych-street, Strand, London	27	Forged metal work.
Hatton, Sons, and Co., late Thompson, Hatton, and Co.	Broadwater Tin Plate Works, Kidderminster.	1	Tin plate.
Hawkins Brothers, late Hale, J., and Co.	Hatherton Works, Walsall	17	Saddlery iron work.
Hawkins, J., and Sons	8, Faulkner-street, Manchester	8	Bleached shirtings.
Hawksworth (Wilson), Ellison, and Co.	Carlisle Works, Sheffield	1	Steel.
Hawksworth (Wilson), Ellison, and Co.	Carlisle Works, Sheffield	15	Pocket and table cutlery.
Haynes and Jefferis	Spon-street, Coventry	17	Velocipedes.
Haynes, T., and Sons	229, Edgware-road, London	20	Hydronette and water bringer.
Heap, Joshua, and Co. Limited	Lee-street, Oldham	21	Pipe and bolt screwing machines.
Heath, Vernon	43, Piccadilly, London	27	Photographs.
Heaton, Butler, and Bayne	14, Garrick-street, London	27	Stained glass.
Henderson, A. L.	49, King William-street and Amersham-road, New Cross, London.	27	Photographs.
Henderson and Co.	Durham	9	Axminster carpets.
Henry, Alexander	12, South Saint Andrew-street, Edinburgh	16	Guns and rifles.
Henry, Alexander	12, South Saint Andrew-street, Edinburgh	16	Breech-loading rifle.
Hepworth, B., and Son	New Wakefield Mills, Dewsbury	9	Lap robes and rugs.

Name.	Address.	Group.	Awarded for
Heymann and Alexander	Stoney-street, Nottingham	10	Lace and curtains.
Hicks, J. J.	8, Hatton-garden, London	24	Clinical instruments.
Hicks, J. J.	8, Hatton-garden, London	25	Meteorological instruments.
Hicks, J. J.	8, Hatton-garden, London	24	Thermometers, &c.
Hicks, J. J.	8, Hatton-garden	20	Water gauges.
Higgin, T., and Co.	33, Tower-buildings West, Liverpool	1	Table salt.
Higgin, T., and Co.	33, Tower-buildings West, Liverpool	3	Salt.
Hitchcock, Williams, and Co.	St. Paul's-churchyard, London	10	Costumes.
Hoe, Richard, and Sons	44, Leadenhall-street, London	10	Hat cases, bags, &c.
Hollick and Co.	Greenwich	2	Portland cement.
Holmes, Joseph E.	London	20	Four cylinder engine.
Holmes, Peyton, and Taylor	43, Borough-road, Southwark, London	20	Air compressor.
Holmes, Peyton, and Taylor	43, Borough-road, Southwark, London	1	Coal and rock cutting machine.
Hooker, J.	104, Upper Thames-street, London	4	Condensed milk.
Hooper and Co.	113, Victoria-street, London	17	Carriages.
Hooper, C., and Co.	Eastington Mills, Stonehouse, Gloucestershire.	9	Cloths and beavers.
Houghton, W. D.	Friars Green Mill, Warrington	1	Steel wire.
Howard and Bullough	Globe Works, Accrington	8	Carding engine.
Howard and Sons	25, Berners-street, Oxford-street, London	7	Furniture.
Howgates, Day, and Holt, Limited	Dewsbury	9	Woollens.
Hudson, Frederick	1, Regent-parade, Ventnor, Isle of Wight	27	Photographs.
Hunter, James	209, King-street, Aberdeen, N.B.	1	Granite monuments.
Hunter, J., and Son	Woodhall Mills, Juniper-green, Edinburgh	4	Oatmeal, pot barley, &c.
Hutchinson, J., and Co.	Widnes, Lancashire	3	Chemicals.
Ind, Coope, and Co.	Burton-on-Trent, Staffordshire	4	Ale.

Name.	Address.	Group.	Awarded for
India Rubber, Gutta Percha, and Telegraph Works Company Limited.	100, Cannon-street, London	25	Rubber goods.
Inman Brothers	Apsley-place, Huddersfield	24	Aërated medicinal waters.
Jacoby, M., and Co.	Broadway, Nottingham	10	Laces.
Jamieson and Co.	Dublin	4	Whiskey.
Jeffrey and Co.	64, Essex-road, Islington, London	27	Designs for wall paper.
Jeffrey and Co.	64, Essex-road, Islington, London	13	Decoration paper.
Jeffreys, Charles	103, Hatton-garden, London	10	Show cases, jewellery boxes.
Jenkinson, A.	10, Princes-street, Edinburgh	2	Glass ware, &c.
Jennings, George	Palace Wharf, Stangate, London	14	Back room appliances.
Jennings, Payne	1, Belgrave-place, Belgrave-square, Rathmines, Dublin.	27	Photographs.
Jennings, Thomas	Brookfield Chemical Works, Cork	3	Magnesia products.
Johnson and Co.	Ditchling Potteries, Sussex	2	Architectural terra cotta.
Johnson, J., and Co.	Charterhouse Works, Sycamore-street, London	10	Shell boxes.
Johnson, Jabez, and Fildes	44, Spring-gardens, Manchester	8	Turkish towels, vestings, &c.
Johnson, J. M., and Sons	London	28	Printing in colours, show tablets, &c.
Johnston, W. and A. K.	4, St. Andrew-square, Edinburgh	28	Maps and illustrations of anatomy.
Jonas, Meyer, and Colver	Sheffield	1	Crucible steel.
Jones, Pryce	Newtown, Montgomeryshire	9	Flannels.
Kay and Hilton	Bankhall Bridge, Liverpool	1	Millstones, &c.
Keen, Robinson, Bellville, and Co.	6, Garlick-hill, Cannon-street, London	4	Mustard.
Kell and Co.	Bradford	9	Lastings.
Kent, George	200, High Holborn	15	Knife-cleaning machines.
Kent, G. B., and Co.	11, Great Marlborough-street, London	10	Brushes.

Name.	Address.	Group.	Awarded for
Kilner Brothers	Great Northern Goods Station, King's Cross, London.	2	Glass bottles, &c.
Kimball and Morton	80, Bishop-street, Anderston, Glasgow	22	Sewing machine.
King Brothers	Stourbridge	2	Gas retorts.
King, William	Gillroyd and Albert Mills, Morley, Leeds	9	Cotton warp cloths.
Kirby, Beard, and Co.	18, Cannon-street, London	10&22	Needles, &c.
Kullberg, Victor	105, Liverpool-road, Islington, London	25	Watches.
Laird, William, and Co.	Canmore Linen Works, Forfar, N.B.	8	Linen fabrics, &c.
Lancaster, Alfred	27, South Audley-street, London	16	Guns.
Lancaster, C. W.	151, New Bond-street, London	16	Breech-loading guns.
Lang, J., and Sons	22, Cockspur-street, Pall Mall, London	16	Guns and rifles.
Lavers, A. H.	Nine Elms, London	2	Portland cement.
Lawrence and Co.	22, St. Mary Axe, London	20	Refrigerators.
Lawson, S., and Sons	Hope Foundry, Leeds	8	Machine for spinning jute.
Lea and Perrins	Worcester	4	Worcestershire sauce.
Ledger, H., and Co.	61 and 63, Lant-street, Borough, London	24	Extract of meat.
Lewis, John	India-buildings, Halifax	9	Carpets.
Liddell and Brierly	Huddersfield	9	Worsted coatings.
Lincoln, Bennett, and Co.	40, Piccadilly, London	10	Hats.
Little, T. W., and Co.	Monk Bridge Mills, Leeds	9	Union cloths.
Liver Alkali Works Company	Lightbody-street, Liverpool	3	Chemicals.
Liverpool Spun Oakum Co.	9, North John-street, Liverpool	19	Machine spun oakum.
Lobb, John	296, Regent-street, London	12	Boots, shoes, &c.
London Stereoscopic and Photographic Company.	108, Regent-street, London	27	Photographs.
Low, Son, and Haydon	148 and 330, Strand, London	3	Toilet soaps.

Name.	Address.	Group.	Awarded for
Lyons, William	Park-street, Manchester	13	Sealing wax.
Lyons, William	Park-street, Manchester	3	Inks.
Macdonald, A. Field, and Co.	Aberdeen Granite Works, Aberdeen, N.B.	1	Granite monuments.
Mackay, John	119, George-street, Edinburgh	3	Varnishes.
Mahony, M., and Brothers	3, Camden-quay, Cork	9	Blarney tweeds.
Mallinson, Thomas, and Sons	Huddersfield	9	Fancy cheviots.
Marling and Co.	Ebley and Stanley Mills, Stroud	9	Cloths and beavers.
Marshall and Co.	Leeds	8	Linen sewing threads, &c.
Martin, Robert	The Village, Old Charlton, Kent	21	Circular cutter.
Martin, William Henry	64 and 65, Burlington-arcade, Piccadilly, London.	10	Umbrellas, canes, &c.
Massey, B. and S.	Openshaw, Manchester	21	Steam hammers and drops.
Matier, H., and Co.	Clarence-place, Belfast	8	Linen fabrics.
Matthews, Ed., and Son	Oxford-street, London	7	Stained glass tiles, monumental brasses.
Maw and Co.	Benthall Works, Broseley, Salop	27	Mosaic work in tiles.
Maw and Co.	Benthall Works, Broseley, Salop	2	Tiles.
Mayer and Meltzer	71, Great Portland-street, London	24	Surgical instruments, &c.
Mayer and Meltzer	71, Great Portland-street, London	15	Pocket knives.
McBride, Robert, and Co.	4, Bedford-street, Belfast	8	Cotton and linen goods.
McCann, John	Beamond Mills, Drogheda, Ireland	4	Oatmeal.
McGee, J. G., and Co.	30, 32, 34, High-street, Belfast	10	Clothing.
McGee, J. G., and Co.	20, 32, 34, High-street, Belfast	9	Rugs and wraps.
McLintock, James, and Sons	Barnsley, Yorkshire	10	Skirts, quilts, &c.
McNaught and Smith	Worcester	17	Pleasure carriages.
McTear and Co.	Corporation-street, Belfast	8	Ship sheathing of jute felting, vegetable tar.
Menier, E.	Southwark-street, Borough, London	4	Chocolate.

Name.	Address.	Group.	Awarded for
Mercer, Thomas	161, Goswell-road, London	25	Marine chronometers.
Middleton, Thomas John	38, Little Queen-street, High Holborn, London.	25	Triple lantern.
Mill Hill Wool and Rag Extracting Company, Limited.	Mill Hill Works, Huddersfield	9	Shoddy and wool.
Millar, John, and Co.	2, South Saint Andrew-street, Edinburgh	2	Glass ware, &c.
Milner, William, and Sons	Union-street, Leek, Staffordshire	9	Sewing silk.
Milward, H., and Sons	Redditch	10 & 22	Needles.
Minton, Hollins, and Co.	Stoke-on-Trent	27	Mosaic work in tiles.
Minton, Hollins, and Co.	Stoke-on-Trent	2	Tiles.
Mirrlees, Tait, and Watson	Scotland-street Ironworks, Glasgow	20	Sugar mills.
Mirrlees, Tait, and Watson	Scotland-street Ironworks, Glasgow	3	Sugar machinery.
Moncrieff, J.	North British Glass Works, Perth, N.B.	20	Gauge glasses.
Morewood, E., and Co.	Coleridge House, Swansea	1	Tin-plate.
Morley, J. and R.	18, Wood-street, Cheapside, London	10	Hosiery, gloves, &c.
Morley, J. and R.	18, Wood-street, Cheapside, London	10	Cloths.
Morson, T., and Son	31, 33, and 124, Southampton-row, Russell-square, London.	3	Chemicals.
Morton, W., Scott, and Co.	Art Furniture Works, Edinburgh	7	Furniture.
Muir, James, and Son	Calton Hill Brewery, Edinburgh	4	Ale.
Murray, Andrew, F.L.S.	67, Bedford-gardens, Kensington, London	28	Illustrations and specimens of galls produced by mites.
Muspratt Bros., and Huntley	Liverpool	3	Chemicals.
Muspratt, J., and Sons	5, Chapel-street, Liverpool	3	Chemicals.
Nairn, M., and Co.	Kirkcaldy, N.B.	8	Floor oil cloth.
Nash, H., and Co.	Tower-buildings North, Water-street, Liverpool.	1	Tin plates.

Name.	Address.	Group.	Awarded for
Neal, John	Edgware-road, London	11	Gold and silver jewellery.
Neal, John, and Co.	Hampden Gurney-street, Portman-square, London.	15	Pyro silver table cutlery.
Negretti and Zambra	Holborn Viaduct, London	25	Thermometers.
Negretti and Zambra	Holborn Viaduct, 45, Cornhill, and 123, Regent-street, London.	25	Microscopes.
Negretti and Zambra	Holborn Viaduct, 45, Cornhill, and 123, Regent-street, London.	25	Meteorological instruments.
Neighbour, G., and Sons	149, Regent-street, London	23	Beehives.
Neilson, Storer, and Sons	Thorn Mills, Johnstone, near Paisley, N.B.	8	Knitting cotton, yarns, &c.
Newcastle Chemical Works Company, Limited.	Newcastle-on-Tyne	3	Soda ash, alkali, &c.
Nicholson, H.	Kilner Deyne-terrace, the Park, Rochdale	10	Cricket balls.
Nicole, Neilson, and Co., late Nicole and Capt.	14, Soho-square, London	25	Watches.
Norman, Carl	Graphic Villa, Tunbridge Wells	27	Photographs.
Norris and Co.	124, Wood-street, London	9	Upholstery silks.
Novello, Ewer, and Co.	London	28	Musical works.
Nusseys and Leachman	Leeds	9	Cloth machine.
Oakey, John, and Sons	Wellington Mill, Westminster Bridge-road, London.	1	Emery grain and flour emery.
Oddy, J., and Sons	Bradford	9	Wools.
Ordnance Survey Office, Major-General Cameron, R.E., C.B., Director-General.	Southampton	26 & 28	Ordnance maps.
Ortner and Houle	3, St. James's-street, London	27	Seals and dies.

Name.	Address.	Group.	Awarded for
Palmer, Samuel	Park House, Grove-street, South Hackney, London	28	Index to the "Times" newspaper.
Patent Nut and Bolt Company	London Works, near Birmingham	15	Bolts, nuts, &c.
Patent Plumbago Crucible Company	Battersea Works, London	2	Dental porcelain, fire clay furnaces.
Patent Selenitic Cement Company (Limited)	Millbank-street, London	2	Mortar and concrete.
Peake, Thomas	The Tileries, Tunstall, Staffordshire	2	Blue brick, and terro metallic wares.
Pearn, Frank, and Co.	Hulme Hill-road, Hulme, Manchester	20	Steam pump.
Pears, A. and F.	91, Great Russell-street, London	3	Transparent soaps.
Pen-yr-Orsedd Slate Quarry Company, Limited.	Carnarvon, North Wales	1	Slate.
Perks, Samuel	High-street, Hitchin, Herts	3	Oil of lavender.
Perkins, A. M., and Son	Seaford-street, Regent's-square, Gray's-inn-road, London.	14	Oven.
Peters, Thomas, and Sons	53, Park-street, Grosvenor-square, London	17	Carriages, &c.
Peyton and Peyton	Bordesley Works, Birmingham	7	Bedsteads.
Phosphor Bronze Company, Limited	139, Cannon-street, London	1	Phosphor bronze.
Pickering, J.	Globe Works, Stockton-on-Tees	20	Pumps, pulleys, &c.
Pigou, Wilks, and Laurence, Limited	11, Queen Victoria-street, London	16	Gunpowder.
Pim Brothers and Company	22, William-street, Dublin	9	Silk and wool poplins.
Pirie, A., and Sons	Stoneywood Works, Aberdeen	13	Papers.
Platt Brothers and Company, Limited	Hartford Works, Oldham	8	Cotton gin.
Poole, James, and Co.	33, Spencer-street, Clerkenwell, London	25	Chronometers and watches.
Potts, Robert, M.A.	Trinity College, Cambridge	28	Educational books.
Pratt, J.	227, Oxford-street, London	4	Sauce.
Price, J. and C., and Brothers	69, Victoria-street, Bristol	2	Stone ware.
Price's Patent Candle Company, Limited	Belmont Works, Battersea, London	3	Fatty acids, candles, &c.
Puckridge, Frederick, and Nephew	530, 534, Kingsland-road, London	3	Goldbeater's skin.

Name.	Address.	Group.	Awarded for
Pullinger, Colin	Selsey, near Chichester	14 & 15	Self-acting sifter, cask stand.
Purdey, James	314½, Oxford-street, London	16	Guns and express rifle.
Ramsey, William	83 and 84, Farringdon-street, London	27	Stained glass, &c.
Rawlins and Son	Brook Mills, Rainhill, Prescot	3	Ultramarine.
Richards, Kearne, and Gasquoine	Sandbach, Cheshire	3	Chemicals.
Richardson, J. N., Sons, and Owden	1, Donegall-square North, Belfast	8	Linen fabrics.
Richardson, Earp, and Slater	Trent and Northgate Brewery, Newark-upon Trent.	4	Ale.
Rickards, Charles A.	Bell Busk Mills, near Leeds	9	Sewing silks.
Rigby, John, and Co.	72, St. James'-street, London	16	Guns and rifles.
Rimmel, Eugène	96, Strand, London	3	Perfumery, &c.
Roberts, William	139, Derby-road, Bootle, near Liverpool	21	Painting machine for laths.
Roberts, C. D.	Alma-street Works, Coventry	17	Spider bicycle.
Robinson, H. P., and Cherill, N. K.	The New Public Buildings, Tunbridge Wells	27	Photographs.
Roe, William Allen	81, Humberstone-gate, Leicester	12	Boots, shoes, &c.
Ross and Co.	7, Wigmore-street, Cavendish-square, London.	25	Microscopes and Photographic Lenses.
Rowney, G., and Co.	52, Rathbone-place, London	3	Colours.
Runcorn Soap and Alkali Company, Limited	6, Water-street, Liverpool	3	Bleaching powder, &c.
Ryder, William Henry	48, Ellis-street, Birmingham	5	Fishing reels, &c.
Sage, Frederick	Gray's-inn-road, London	7	Air-tight show-cases, and velvet stands for jewellers' windows.
Salter, Samuel, and Co.	Home Mills, Trowbridge, Wilts	9	Fancy cassimeres.
Sandeman, F. S.	Manhattan Works, Dundee, N.B.	8	Linen and jute yarns.
Sanderson and Procter	Shore Works, Huddersfield	20	Automatic fire extinguisher and alarm.

Name.	Address.	Group.	Awarded for
Sangster and Co.	140, Regent-street, London	10	Umbrellas, parasols.
Sanson, R. B.	87, Globe-road, Mile End-road, London	22	Cloth cutting machine.
Saxby and Farmer	Canterbury-road, Kilburn, London	18	Railway signals.
School of Art Needlework, Royal	Exhibition-road, South Kensington, London	10 & 27	Specimens executed by pupils.
Schorlemmer, Professor	Manchester	3	Hydro-carbons, &c.
Schwabe, Salis, and Co.	41, George-street, Manchester	8	Printed cotton fabrics.
Scott, W. and C., and Son	Premier Gun Works, Lancaster-street, Birmingham.	16	Guns.
Sewill, J.	20, Cornhill, Royal Exchange, London	25	Chronometers and watches.
Shackleton and Binns	Halifax	—	Warp tying machines.
Shaw, William	3, Sheldon-street, Bayswater, London	13	Card press.
Shearer, Hugh	21, Great George-street, London	21	Stone dressing machine.
Sheldon and Fenton	12, King-street, Cheapside, London	9	Sewing silk.
Shoolbred and Co.	Tottenham Court-road, London	7	Furniture.
Siebe and Gorman	17, Mason-street, Westminster-Bridge-road, London.	20	Diving apparatus.
Siemens Brothers	12, Queen Anne's-gate, London	25	Submarine telegraph cable.
Siemens, C. William	12, Queen Anne's-gate, London	1	Regenerative gas furnace.
Siemens, C. William	12, Queen Anne's-gate, London	25	Pyrometers.
Simon, May, and Co.	Weekday Cross, Nottingham	10	Embroidered curtains, &c.
Simon, May, and Co.	Weekday Cross, Nottingham	10	Goring webbing, &c.
Simpson and King	7, York-street, Manchester	8	Printed cotton fabrics.
Singer, J. W., and Son	Frome, Somerset	7	Church ornaments.
Smith, David, and Co., Limited	Kensington Works, Halifax	9	Shoddy and wool.
Smith, Dillwyn	153, Duke-street, Liverpool	14	Ship disinfecting apparatus.
Smith, Dillwyn	153, Duke-street, Liverpool	20	Automatic stoker.
Smith, F., and Co.	Caledonia Works, Halifax	1	Steel wire.

Name.	Address.	Group.	Awarded for
Smith, George John	The Terrace, Church-road, Upper Norwood, London.	10	Irish laces.
Smith, James, and Son	Astwood Bank, near Redditch	22	Needles.
Smith, James, and Son	Astwood Bank, near Redditch	10	Hand sewing needles.
Smith, John Wright	121, Belgrave-gate, Leicester	22	Knitting machine needles.
Smith, T. and H., and Co.	21, Duke-street, Edinburgh	4	Ginger beer and lemonade.
Smith, T. and H., and Co.	21, Duke-street, Edinburgh	4	Essence of coffee and fruit essences.
Smith, T. and H., and Co.	21, Duke-street, Edinburgh	3	Chemicals.
Smith, Thomas, and Co.	61, Wilson-street, Finsbury, London	4	Ornamental confectionery.
Smith, William, and Sons	Barnard Castle, Durham	26	Street-sweeping machine.
Smith, William, and Sons	Dalham Iron Works, Warrington	15	Pliers, vices, &c.
Smith, William, and Sons	Dalham Iron Works, Warrington	1	Steel wire.
Smyth and Co.	36 and 37, Lower Abbey-street, Dublin	10	Balbriggan hosiery.
Soper, William	23, Friar-street, Reading	16	Long range rifles.
Spence, Peter	Oldham-road, Manchester	3	Chemicals.
Stansfield, Brown, and Co.	Bradford, Yorks	9	Shoe lastings.
Star Plate and Universal Polishing Powder Company.	6, Gracechurch-street, London	1	Polishing powder.
Starkey, Brothers	Huddersfield	9	Beavers.
Steel and Garland	Wharncliffe Works, Sheffield	14	Steel grates, with porcelain tiles, fenders, and encaustic tiled plinth.
Stephens, H. C.	171, Aldersgate-street, London	3	Inks.
Stephenson, Blake, and Co.	Allen-street, Sheffield	13	Sheets of printing type.
Stevens, Thomas	Stevengraph Works, Coventry	9	Silk ribbons, &c.
Stiff, J., and Sons	High-street, Lambeth, London	2	Stoneware.
Storer, David, and Sons	Sydney-street, Glasgow, N.B.	3	Colours.
Sunday School Union	56, Old Bailey, London	28	Works for Sunday schools.

Name.	Address.	Group.	Awarded for
Sutcliffe, James S.	Bacup, Lancashire	4	Middlings purifier.
Swaine and Adeney	185, Piccadilly, London	10 & 17	Whips.
Swansea Tin Plate Co.	Tin Plate Works, Swansea	1	Tin plates.
Swainson, Birley, and Co.	Cheapside, London	10	Cotton shirtings, long cloths.
Tangye Brothers	Cornwall Works, Soho, Birmingham	20	Screw lifting jacks, &c.
Taylor, John, and Son	- - - - -	9	Coatings.
Telegraph Construction and Maintenance Company.	London	25	Specimens of submarine telegraph cables.
Templeton, J., and Co.	William-street, Glasgow, N.B.	9	Carpets.
Templeton, J. and J. S.	Crownpoint-road, Glasgow, N.B.	9	Carpets.
Thackrah and Co.	Dewsbury	9	Calf's hair coatings.
Thompson, C.	33, Newington Butts, London	17	Three-wheeled perambulator.
Thomson, W. S., and Sons	Cheapside, London	10	Corsets.
Thorn, Charles	St. Giles' Gate, Norwich	17	Carriages.
Tinworth, George	122, Hill-street, Walworth, London	27	Terra cotta bas reliefs on scriptural subjects.
Tomkinson and Adam	Kidderminster	9	Carpets.
Tress and Co.	3, 5, and 7, Stamford-street, London	10	Pith and felt hats.
Turner, Charles, and Son	7, Broad-street, Bloomsbury, London	3	Linseed oil, turpentine, &c.
Turner, George, and Co.	94, Gracechurch-street, London	10	Military equipments, &c.
Turner and Co.	- - - - -	21	Smiths' tools.
Typographic Etching Company	Farringdon-street, London	27	Engravings, typographic process.
Ullathorne and Co.	Barnard Castle, Durham	8	Shoe threads.
Usher, Rufus	Bodicote, near Banbury, Oxfordshire	4	Rhubarb.
Veitch, J., and Sons	Royal Exotic Nursery, King's-road, Chelsea, London.	29	Plants.

Name.	Address.	Group.	Awarded for
Veitch, J., and Sons	Royal Exotic Nursery, King's-road, Chelsea, London.	29	Trees and shrubs.
Walter, John, M.P.	"Times" Office, Printing House-square, London.	13	"Walter" printing press.
Ward, Marcus, and Co.	67 and 68, Chandos-street, Strand, London	27	Chromo-lithographic illustrations.
Ward, Marcus, and Co.	67 and 68, Chandos-street, Strand, London	13	Stationery.
Ward and Payne	West-street, Sheffield	15	Chisels, braces, &c.
Warner, R.	8, Crescent, Cripplegate, London	28	Books, 2 vols. Orchidaceous plants.
Watcombe Terra Cotta Company, Limited	St. Mary Church, Torquay, South Devon	2	Red terra cotta.
Waterer, Anthony	Knap Hill Nursery, Woking, Surrey	29	Trees and shrubs.
Waterston, G., and Son	Hanover-street, Edinburgh	13	Sealing wax.
Webb, Edward, and Sons	Copenhagen-street, Worcester	9	Hair cloth.
Webley, P., and Son	82, Weaman-street, Birmingham	16	Breech loading musket.
Webley, P., and Son	82, Weaman-street, Birmingham	16	Breech loading fire arms.
Welch, Margetson, and Co.	16 and 17, Cheapside, London	10	Scarfs, ties.
West Cumberland Iron and Steel Company	Workington, Cumberland	1	Bessemer pig iron and steel.
Westley-Richards and Co.	Birmingham	16	Hammerless breech loading guns.
Wheeler, Edmund	48, Tollington-road, Holloway, London	25	Preparations for the microscope.
White, J. and J.	80, Wilson-street, Glasgow	3	Bichromate of potash.
Whitwell, Thomas	Thornaby Iron Works, Stockton-on-Tees	1	Regenerative hot blast stove.
Wilkinson, W., and Sons	Grimesthorp, Sheffield	15 & 23	Sheep and hedge shears.
Williams, B. S.	Victoria and Paradise Nurseries, Upper Holloway, London.	29	Hothouse plants.
Williams, B. S.	Victoria and Paradise Nurseries, Upper Holloway, London.	29	Ferns, &c.
Williams, M.	Britannia Varnish Works, Wigan	3	Varnish, paints, &c.
Wills, A. W.	Park Mills, Nechells, Birmingham	23	Tools, hoes, axes, &c.
Wilson, Newton, and Co.	144, High Holborn, London	7	Washing machine.

Name.	Address.	Group.	Awarded for
Wilson, T. and D., and Co.	145, Ingram-street, Glasgow	8	Cotton fabrics.
Wilson, Walker, and Co.	Sheepscar Works, Leeds	12	Leather.
Windover, C. S.	32 and 33, Long Acre, London	17	Pleasure carriages.
Wood and Ivery	Albion Brick Works, West Bromwich, Staffordshire.	2	Blue brick and terra metallic ware.
Wortley, Colonel Stuart	30, Grove End-road, St. John's Wood	27	Photographs.
Wostenholm and Son, Limited	Washington Works, Sheffield	15	Pocket knives, &c.
Wouldham Cement Company	10A, King's Arms-yard, Moorgate-street, London.	2	Portland cement.
Wright, Herbert, and Co.	Maxton Brewery, near Dover	4	Ale.
Wright, P., and Sons	Constitution Hill Works, Dudley, Worcestershire.	21	Anvils and vices.
Wright, William	Vulcan Foundry, Coatbridge, Scotland	20	Hot water boilers.
Wright and Mansfield	104, New Bond-street, London	7	Furniture.
Wright and Mansfield	104, New Bond-street, London	27	Interior decorations.
Young and Strang	Glasgow	3	British gum, &c.
York, F.	87, Lancaster-road, Notting Hill, London	27	Photographs.
York Street Flax Spinning Company	Belfast	8	Linen fabrics.

BRITISH PAINTERS, ENGRAVERS, AND ARCHITECTS WHO HAVE RECEIVED AWARDS.

OIL COLOUR PAINTINGS.

	Group.		Group.		Group.		Group.
Boughton, G. H.	27	Frith, William Powell, R.A.	27	Leighton, Frederick, R.A.	27	Perugini, Charles Edward	27
Clark, J.	27	Graham, Peter	27	Leslie, George D., R.A	27	Poole, P. F., R.A.	27
Cole, Vicat, A.R.A.	27	Grant, Sir Francis, P.R.A.	27	Mutrie, Miss A. F.	27	Pott, L. G.	27
Elmore, Alfred, R.A.	27	Hardy, Heywood	27	Mutrie, Miss M. D.	27	Rivière, B.	27
Faed, Thomas, R.A.	27	Holl, Frank	27	Nicol, Erskine, A.R.A.	27	Stone, Marcus	27
Fildes, S. Luke.	27	Hunter, Colin	27	Orchardson, W. Q., A.R.A.	27	Tadema, L. Alma, A.R.A.	27

SCULPTURE—DIE SINKING.

		Group.	
Wyon, J. S. and A. B.	Regent-street, London	27	Medal and seals.

CARTOONS FOR MOSAICS.

	Group.
Poynter, Edward J., R.A.	27

WATER COLOUR PAINTINGS.

	Group.		Group.		Group.
Callow, W.	27	Linton, J. D.	27	Newton, A. P.	27
Jopling, J. M.	27	Marks, H. Stacy, A.R.A.	27	Tadema, L. Alma, A.R.A.	27

Name.	Address.	Group.	Awarded for
Barlow, T. Oldham, A.R.A.		27	Engravings.
Du Maurier, George		27	Pen and ink drawings for "Punch."
Edwards, Edwin		27	Etchings.
Evershed, Arthur		27	Etchings (Dry Point).
"Graphic, The"		27	Black and white drawings and wood engravings.
Haden, Francis Seymour		27	Etchings on copper.
Heseltine, J. P.		27	Etchings.
"Illustrated London News"		28	Specimens illustrating the Art Department of "Illustrated London News."
Leighton, John, F.S.A.		27	Etchings printed from reliefs.
Lewis, Charles G.		27	Engravings.
Saddler, John		27	Line engravings.
Swain, Joseph		27	Wood engravings.
Hems, Harry	69, Paris Street, Exeter	7	Alabaster statue, carved oak chest.

Name.	Address.	Group.	Awarded for
Aitchison, George, F.R.I.B.A.		27	Industrial designs for furniture.
Burges, William		27	Designs for tower, &c.
Cooper, Henry		27	Interior decoration, St. George's House, Fairmount Park.
Penrose, F. C., M.A., F.R.A.S.		27	Designs for decoration of St. Paul's Cathedral.
Wyatt, T. H.		27	Designs for houses.
	LIVE STOCK.		
Ackers, Benjamin St. John	Prinknash Park, Painswick, Gloucestershire	31 & 33	Sheep, cattle (two medals).
Aylmer, Hugh	West Dereham Abbey, Norfolk	32	Sheep.
Cryer, Major		35	Pigeons.
Cooper, J. C.		35	Game fowls.
Druce, A. F. M.	Eynsham	32	Sheep.
Overman, H.	Weasenham, Brandon, Norfolk	32	Sheep.
Swanwick, Russell	Royal Agricultural College Farm, Cirencester	32	Sheep.
Walsingham, Lord	Merton Hall, Thetford, Norfolk	32	Sheep.
Cooper, J. C.	Cooper Hill, Limerick	34	Imported Irish setter bitch.
Cooper, J. C.	Cooper Hill, Limerick	34	Imported Irish setter dog.
Cooper, J. C.	Cooper Hill, Limerick	34	Imported Irish setter dog.
Greenhill, Robert S.	Dublin	34	Imported Irish setter dog.
Leech, Major Arthur Blennerhasset		34	Irish terrier.
Millner, J. K.	Blackrock, county Dublin	34	Imported Irish setter bitch.

Special Awards for Services to American Executive in Machinery Department.

Galloway, W. J., & Sons.
Aveling & Porter.
Appleby Brothers.
E. Green & Son.
Frank Pearn & Co.
Jonathan Pickering.

Special Awards.

Irish Rifle Team.

Major Arthur Blennerhasset Leech, Captain.
Lieut. Alexr. Ward.
Lieut. George Fenton.
William Rigby.
Joshua K. Millner.
Edmund Johnson.
Henry Dyas.
W. G. D. Goff.
W. R. Joynt.

Scottish Rifle Team.

Col. J. H. A. Macdonald, Captain.
William Thorburn.
R. MeVittie.
D. Fraser.
Dr. J. Mitchell.
Peter Rae.
William Clark.
Thomas Whitelaw.
Martin Boyd.

Dublin University Rowing Club.

Thames Crew [*Watermen*].

AWARDS TO EXHIBITORS FROM INDIA, THE DOMINION OF CANADA, AUSTRALASIA, AND OTHER COLONIES.

India	9
The Dominion of Canada	480
Bahamas	7
Bermudas	7
British Guiana	5
Cape of Good Hope	22
Ceylon	2
Fiji	1
Gold Coast Colony	1
Jamaica	31
Mauritius	3
New South Wales	87
New Zealand	30
Queensland	61
South Australia	45
Straits Settlements	1
Tasmania	29
Trinidad	6
Victoria	128
Total	955

List of Awards to Colonial Exhibitors.

Name.	Address.	Group.	Awarded for
BAHAMAS.			
Gardner, Mrs. E. A.	Nassau	5	Shell work.
Robertson, Mrs. S. E.	Nassau	5	Shell work.
Robinson, C. H.	Nassau	4	Honey.
George, J. S.	Nassau	4	Vegetable wax.
Sawyer, R. H. and Co.	Nassau	6	Woods, barks, &c.
Sawyer, R. H.	Nassau	4	Sponges.
Government of the Bahama Islands	-	—	Collective Exhibit.
BERMUDAS.			
Government of Bermuda	Hamilton	5	Collection of live fish.
Government of Bermuda	Hamilton	5	Shells, corals, sponges, &c.
Government of Bermuda	-	19	Floating Dock, Bermuda.
Ness, P.	Hamilton	1	Building stones.
Tucker, J. Fowle	Hamilton	4	Arrowroot.
Hayward, J. Ming	-	6	Arrowroot.
Government of Bermudas	-	—	Collective Exhibit.
BRITISH GUIANA.			
Ogle Plantation	-	3	Sugar.
La Bonne Intention Plantation	-	3	Sugar.
Leonora Plantation	-	3	Sugar.
Great Diamond Plantation	-	3	Sugar.
Government of British Guiana	-	—	Collective Exhibit.

Name.	Address.	Awarded for
	CANADA.	
	I.—Minerals, Mining, Metallurgy, and Machinery.	
Somerville, P. T.	Arnprior, Ontario	Monuments of dark clouded marble of Arnprior.
New Rockland Slate Co.	Montreal	Roofing slate and slate slabs from Melbourne, Canada.
Ontario Lithographic Stone Co.	Marmora, Ontario	Lithographic stones.
Robertson, R.	Halifax, N.S.	Gold specimens.
Seaman, A., and Co.	Lower Cove, N.S.	Grindstones.
Daniel and Boyd	St. John, N.B.	Block of freestone.
Dorchester Union Freestone Co.	Dorchester, N.B.	Building stone.
Forsyth, Robert	Montreal	Red granite monuments, &c., from Gananoque.
McDonald, George J., and Co.	Cornwallis, N.S.	Building stone.
Kelly, John	Belleville, Ontario	Lithographic stones.
Bay of Fundy Red Granite Co.	St. George, N.B.	Wrought red granite.
Gray, Young, and Sparling	Eclipse Well, Seaforth, Ontario	Refined salt.
Waterman Brothers	London, Ontario	Petroleum.
Lake George Antimony Co.	Prince William, N.B.	Regulus of antimony.
Goodfellow, Joseph	North Esk, N.B.	One large grindstone.
Dominion of Canada Plumbago Co.		Graphite and products manufactured therefrom.
Danville Slate Co.	Danville, Quebec	Slate.
Cowan, Alexander	Brockville, Ontario	Phosphate of lime, pyrites, &c.
Hopewell Quarry Co.	Hopewell, N.B.	Sandstone.

LIST of AWARDS to COLONIAL EXHIBITORS—*cont.*

Name.	Address.	Awarded for
Stuart, W. W.	Montreal	Native copper.
Rankin, John	Actonvale	Collection of coloured slates.
Gatling Gold Mining Co.	Marmora, Ontario	Gold ores.
Honeyman, Dr.	Halifax, N.S.	Geological collection.
Steel Company of Canada	Londonderry, N.S.	Ores, iron, and steel.
Nova Scotia Section of Canada Commission	Nova Scotia	Collection of building stones.
Nova Scotia Advisory Board	-	Coals.
Geological Survey of Canada	-	Geological collection.
Silver Islet Mining Co.	Silver Islet, Ontario	Silver and silver glance.
II.—*Pottery, Glass, Artificial Stone, &c.*		
St. John Stone Chinaware Co.	Quebec	White "Granite" wares.
Lee Brothers	St. John, N.B.	Common hard bricks.
Albert Manufacturing Co.	Hillsborough, N.B.	Raw and calcined gypsum.
Bulmer and Sheppard	Montreal	Common bricks.
McKay, William	Ottawa	Hydraulic cement.
Tiffany, George Sylvester	London, Ontario	Brick and tile making machine.
Gauvreau, P., and Co.	Quebec	Hydraulic cement and artificial stones.
Dominion of Canada Plumbago Co.	Buckingham	Plumbago crucibles.
III.—*Chemistry and Pharmacy, with the Apparatus.*		
Waterman Brothers	London, Ontario	Paraffine, &c.
Troop, O. V., and Co.	St. John, N.B.	Vinegar.
Ramsay, T.	Montreal	Pigment.

Name.	Address.	Awarded for
Ramsay, A., and Son	Montreal	Paints.
Lyman Brothers and Co.	Toronto	Chemicals.
Lyman, Clare, and Co.	Montreal	Pigments, oils, &c.
Lefevre, M.	Montreal	Vinegar.
International Salt Co.	Goodrich, Ontario	Salt.
Hessin, William	Toronto, Ontario	Bonbons, &c., of sugar.
Harrison and Evans	Goodrich, Ontario	Salt.
Gray, Young, and Sparling	Seaforth, Ontario	Salt.
Freeland, Robert	Montreal	Machine for boiling soap under pressure.
Buchanan Mineral Co.	Hamilton, Ontario	Mineral paint.
Morse, George W., and Co.	Toronto	Soaps and tallow-candles.
Hood, A. W., and Son	Montreal	Soaps.
Cowan, Alexander	Brockville	Super-phosphate and its materials.
Albert Toilet Soap Co.	Montreal	Soaps and oils.
	IV.—*Animal and Vegetable Products.—Machinery.*	
Mearns, Matthew	Durham, Ontario	Wheat.
James, James A.	Nilestown, Ontario	Factory cheese.
Hopkins, E. N.	Ingersoll, Ontario	Factory cheese.
Elliott, James	Brownsville, Ontario	Factory cheese.
Dawes, Samuel	Whitby, Ontario	Wheat.
Dunn, William	Ingersoll, Ontario	Butter.
Mabee, O. P.	Courtland, Ontario	Factory cheese.
Chalmers, David	Stratford	Factory cheese.
Bell, Adam E.	Gorra and Blandford, Innerkip	Cheese.
Slater, R. P.	Galt, Ontario	Malt.

Name.	Address.	Awarded for
McEvoy, William	Woodburn, Wentworth, Ontario	Honey.
Ballantyne, Michael	Ingersoll, Ontario	Butter.
Hettle and Inglis	Teeswater, Ontario	Butter.
Robins, J. A.	Avon	Cheese.
Hunter, E.	Mount Elgin	Cheese.
Paddon, Anna	Beachville	Cheese.
Williams, James J.	Galloway, Ingersoll	Cheese.
Mathison, Hugh	Embro	Cheese and factory cheese.
Hunter, E.	Mount Elgin	Cheese.
Chambers, D.	Stratford	Cheese.
Morton, David	Cassels	Cheese and factory cheese.
Ballantyne, Thomas	Stratford, Ontario	Cheese and factory cheese.
Huxley, William	Fullerton	Cheese.
Butler, John	Mount Elgin	Cheese.
Cahoe, J. W.	Nine Durham	Cheese.
Cahoe, D. B.	Holbrook	Cheese.
Dunn, Peter	Ingersoll	Cheese.
Brodie and Harvey	Montreal	Graham flour, &c.
Smith, George	Verschoyle	Cheese.
Howland, W. P.	Toronto	Wheat.
Christie, Brown, and Co.	Toronto	Biscuits and crackers.
Rankine, T., and Sons	St. John, N.B.	Fancy biscuits.
Collins, James	Erin, Ontario	Wheat.
Sugg, R.	Minto, Ontario	Wheat.
Campbell, John	Hullett, Ontario	Wheat.
Tuck, R.	Nelson, Ontario	Wheat.
Beattie, William	Nickol, Ontario	Wheat.

Name.	Address.	Awarded for
Catelli Brothers	Montreal	Macaroni soup pastes, &c.
Spinelli, M. B.	Montreal	Macaroni soup pastes, &c.
Wilkinson, William	Ingersoll	Cheese.
Losee, H. S.	Norwich	Cheese.
Anderson, William	Woodstock	Cheese.
Shirk and Snider	Bridgeport, Ontario	Flour from winter wheat.
Nuams, Walker	Durham, Ontario	Wheat.
O'Neal, William P.	Watertown, Ontario	Wheat.
Murton, James H.	Salesbury, N.B.	Wheat.
Skinner, Thomas J.	Cowitcher, B. Col.	Wheat.
Schearer, Robert	Niagara, Ontario	Wheat.
McGill, William	York County, Ontario	Wheat.
Bell, James	Tuckersmith, Ontario	Wheat.
Bell, William	Tuckersmith, Ontario	Wheat.
Seip, Jacob	Petersburg, Ontario	Wheat.
Stonehouse, George	Scarborough, York County	Barley.
Moyer, C. H.	Campden, Ontario	Bohemian oats.
McKay, Thomas, and Co.	Ottawa	Oatmeal.
Warton, H.	Guelph	Oatmeal.
Rose, Lawrence	Georgetown	Buckwheat flour.
Scott and Co.	Highgate	Oatmeal, four varieties.
Aspden and Pritchard	London	Oatmeal, four varieties.
Wilson, James	Fergus	Oatmeal.
Tilson, E. D.	Tilsonburg	Oatmeal and buckwheat flour.
Starr Mills	Bridgetown	Buckwheat flour.
Francis, P.	Brooklyn	Oatmeal, three samples, different varieties.
Howard and Northwood	Chatham	Malt.

LIST of AWARDS to COLONIAL EXHIBITORS—*cont.*

Name.	Address.	Awarded for
Labatt, John	London	Malt.
Canadian Meat and Produce Co.	Sherbrook, Quebec	Pickles, sauces, and soups.
Smith, Lamus	Chatham, Ontario	Oats.
Manderson, Thomas	Myrtle, Ontario	Oats.
Anderson, Charles	Tyndonaga, Hastings, Ontario	Oats.
Taylor, Mrs. Jane	Stanley, York, N.B.	Oats.
Stewart, John	Horton, Renfrew	Rye.
Howser, T. M.	Camden, Lincoln County, Ontario	Clover seed.
Smith, William	Fairfield Plains, Ontario	Clover seed.
Agur, Robert	Pond Mills, Ontario	Coloured cheese.
Chisholm, John	East Nissoura, Ontario	Coloured cheese.
Wilkinson, William	Ingersoll, Ontario	Coloured cheese.
Chalcroft, Mark	Thamesford	Cheese, factory cheese, &c.
Williams, J. F.	Galloway, Ontario	Pale cheese for shipping, uncoloured cheese, &c.
Bell, Adam	Blanford	Pale cheese for shipping, uncoloured cheese, &c.
Manning, William	Belmont, Ontario	Coloured cheese.
Mission of Chipegan	Lake Alataska	Wheat and barley.
Caswell, Edward	Ingersoll, Ontario	Hams, breakfast bacon, smoke-dried sides.
Netz, Christian	Halifax, N.S.	Bologna preserved in lard.
Woodrell, W.	Halifax, N.S.	Mess beef.
Canadian Meat and Produce Co.	Sherbrook	Canned meat in great variety.
Edwardsburg Starch Co.	Edwardsburg	Starch.
Noble, R. B.	Richebucto, N.B.	Preserved fruit (blueberries).
Butcher, J. W.	Halifax, N.S.	Preserved fruit (strawberry and cranberry jelly).

List of Awards to Colonial Exhibitors—*cont.*

Name.	Address.	Awarded for
Brian, J. D.	Restigouch, N.B.	Canned roast beef.
Netz, Christian	Halifax, N.S.	Smoked goose, ham, ox tongue.
Davis, S., and Co.	Montreal	Cigars.
Ireland, James	Ingersoll	Cheese.
Manderim, T.	Myrtle, Ontario	Wheat.
McGill, R.	Erin, Ontario	Wheat.
Stewart, Alexander	Brussels, Ontario	Wheat.
Currie, George	Beachville, Ontario	Factory cheese.
Mackenzie, Alexander	Kastnerville, Ontario	Factory cheese.
Gillard, William	Tavistock, Stratford	Factory cheese.
Caswell, E.	Ingersoll, Ontario	Cheese.
Hemmingway, P.	Corinth, Ontario	Cheese.
Hankins, Thomas	Holbrook, Ontario	Cheese.
Weatherstone, W., and Co.	Toronto, Ontario	Flour.
King, J. G.	Canada, Port Hope, Toronto, Ontario	Flour from winter wheat.
Advisory Board of Prince Edward's Island	Charlottetown	Oats.
Indians of Douglass Lake	British Columbia	Wheat.
Labatt, John	London, Ontario	Ale and stout.
Davies, T., and Brother	Toronto	Ale and porter.
Cosgrove and Co.	Toronto	Bottled ale.
Farrell, Agnew L.	Cayuga, Ontario	Wines.
Hustings, James	White Church	Wine.
Blackwood, R., and Co.	Montreal	Ginger ale.
Casci, V.	St. Vincent, Toronto	Cherry wine.
Knight, James	Halifax, N.S.	Brandy of cherry.
Wine Growers' Association	Toronto	Wine and brandy.
Nixon, D.	Allisonville, Ontario	Wine.

List of Awards to Colonial Exhibitors—*cont.*

Name.	Address.	Awarded for
	V.—*Fish and Fish Products.—Apparatus of Fishing.*	
Scribner, D.	St. John, N.B.	Rods for catching salmon, &c.
St. John, F.	Victoria, B.C.	Specimens of prepared fish.
Ewen and Wise	New Westminster, Frozier R.	Isinglass.
Andrews and Co.	Halifax, N.S.	Canned lobster and mackerel.
Noble, R. B.	Richebucto	Canned lobster.
Chebucto Packing Co.	Halifax, N.S.	Canned lobster.
Educational Department	Toronto	Prepared fish.
Doyle, T.	Halifax, N.S.	Tongues and sounds, herring, mackerel.
Bain, J. D.	Rustigoucho, N.B.	Canned mackerel, lobster, and salmon.
Holbrook and Cunningham	Victoria, B.C.	Canned salmon.
Barber, James	Halifax, N.S.	Canned lobster and canned mackerel.
Loggie, A., and Co.	Victoria, B.C.	Salted salmon, trout, and oolachan in barrels and kits.
Crowe, A. S.	Halifax, N.S.	Salted and dried haddock, and smoked herring, &c.
May, S. B., M.D.	Toronto, Ontario	Prepared fish.
	VI.—*Timber, Worked Lumber, Parts of Buildings.*	
Fairbanks and Hawes	St. John, N.B.	Doors, sash, blinds, and newel posts.
Greig, A. N.	Montreal	Painted imitations of wood and marbles.
Bronson, J. Weston	Ottawa	Pine lumber.
Pike and Richardson	Chatham, Ontario	Barrel hoops.
Hall, G. B.	Montmorency Mills, Quebec	Pine boards.
Cusack, H. P.	Newbury, Ontario	Barrel hoops.

Name.	Address.	Awarded for
Young, Levi	Ottawa	Pine lumber.
Rochester, John	Ottawa	Pine lumber.
Perley and Pattie	Ontario	Pine lumber.
Newell, George	Ottawa	Ash pillars.
Oliver, John	Ontario	Worked lumber.
Quebec Advisory Board	-	Worked lumber.
Wilson, Gilmore, and Co.	St. John, N.B.	Marbleized slate mantels.
Rennie, William	Toronto	Garden and other seeds.
Allen, J. H.	Pictou	
Advisory Board of Nova Scotia	Halifax, N.S.	Exhibit of seeds.
Advisory Board of Nova Scotia	Halifax, N.S.	Various seeds other than cereals.
Advisory Board of Manitoba	Manitoba	Seeds, wild hops, wild tea, &c.
Advisory Board of Ontario	-	Sundry seeds other than cereals.
Council of Agriculture of Quebec	Montreal	Sundry field seeds.
Hendry, Charles	Conestoga, Ontario	Linseed.
VII.—*Furniture, Upholstery, Wooden Ware.*		
Roy, Joseph, and Co.	Montreal	Invalid chair.
Lee, William	Toronto	Furniture.
Wright, J.	Montreal	Parquetry flooring.
Tuerk, Q. W.	Boslen, Ontario	Clock case and chandeliers in oak.
VIII.—*Cotton, Linen, and other Fabrics, &c.*		
Dundas Cotton Mills	Hamilton	Brown sheetings and seamless bags.
Fuller, S. S.	Stratford, Ontario	Flax.

Name.	Address.	Awarded for
	IX.—*Wool and Silk Fabrics.—Machinery.*	
Powers, S. H.	N. B.	Hand-loom.
Fisher, T. Stavert	Toronto, Ontario	Woollens.
Harvey, John & Co.	Hamilton, Ontario	Wool.
Toronto Tweed Co.	Toronto	Woollens.
Lomas, Adam, and Son	Sherbrook	Flannels.
Willett, Samuel T.	Chambly	Flannels.
Mills and Hutchinson	Montreal	Woollens.
Wardlaw, John	Galt, Ontario	Woollen yarns.
Rosamond Woollen Co.	Almonte	Woollens.
Smith and Wilby	Toronto	Flannels.
Oxford Woollen Mills	Oxford, N.S.	Woollens.
Winger, H.	Elmira, Ontario	Flannels.
Woodworth, A. L.	St. John, N.B.	Woollen yarns.
	X.—*Clothing, Furs, India-Rubber Goods, &c.*	
Thibault, Lanthier, and Co.	Montreal	Furs, ermine muffs, &c.
Hudson Bay Co.	Montreal	Raw furs, Esquimaux seal-skin coat, &c.
Kaiser, C., and Son	Halifax	Natural raccoon and black bear robes, &c.
Reynolds and Volkel	Montreal	Wolf robes, rugs, &c.
Skelton, Tooke, and Co.	Montreal	Shirts, &c.
Brown and Clagget	Montreal	Costumes for ladies.
May, J. S.	St. John, N.B.	Gents' clothing.
Boeck, C.	Toronto, Ontario	Brushes.
Whitehead and Turner	Quebec	Brushes.

Name.	Address.	Awarded for
Grind, G. R.	London, Ontario	Brooms and whisks.
Clarke, W. E.	Toronto, Ontario	Trunks, &c.
Farrell, Miss Kate	Toronto, Ontario	Carriage rugs.
Grey Nuns of Montreal	Montreal	Embroidered handkerchief.
General Hospital	Quebec	Artificial flowers.
Convent Jesus and Mary	Quebec	Embroidery, priests' vestments.
Hochelaga Convent	Montreal	Embroidery, priests' vestments.
McDonald, Mrs. D. B.	Montreal	Gobelin tapestry.
Fairbanks, Miss Isabella	Halifax, N.S.	Lace handkerchief.
Sutcliffe, Mrs.	Halifax, N.S.	Needlework, "Last Supper."
Constant, Mrs.	Halifax, N.S.	Leather work for mirror frame.
Farrel, Misses	Halifax, N.S.	Fancy wool work.
Wickstead, Mrs. R. A.	Ottawa	Point laces.
Farquharson, Miss Lizzie	Whitby	Pointing on velvet, designs for painting.
Park, Miss	Watertown	Knitting and tatting.
Neville, Mrs.	Ottawa	Leather work.
Smith, Miss Sidney	Dundas	Lace work handkerchief.
Turnbull T.	Galt, Ontario	Knitted underwear.
Nunn, Mrs.	Belleville	Point lace.
McCrae and Co.	Guelph, Ontario	Hosiery.
Ancaster Knitting Co.	Hamilton, Ontario	Knitted and fancy goods.
Taylor, R. F., and Son	Toronto, Ontario	Men's clothing.
Furnival, T. G.		Clothing.

XI.—*Jewellery, Watches, Silverware, Bronzes, &c.*

No awards to Canadian Exhibitors.

List of Awards to Colonial Exhibitors—*cont.*

Name.	Address.	Awarded for
	XII.—*Leather and Manufactures of Leather, &c.*	
Ramsey, David	Cobourg, Ontario	Boots and shoes.
Craig, William, and Son	Port Hope, Ontario	Leather.
Heath and Northey	Montreal	Sole leather.
Moseley and Ricker	Montreal	Leather.
	XIII.—*Paper, Stationery, Printing, and Bookmaking.*	
Saint Croix River Mills	Saint Croix, N.S.	Binders' pasteboard.
Perrault, Louis, and Co.	Montreal	Commercial printing.
Canada Paper Company	Montreal	Paper.
	XIV.—*Apparatus for Heating, Lighting, &c.*	
McElvey, James	St. Catherine's	Cream gatherer.
Anderson, Alexander		Bread knife.
	XV.—*Builders' Hardware, Tools, Cutlery, &c.*	
Dates Patent Steel Co.	Toronto	Axes and edge tools.
Warnock, Jos., and Co.	Galt, Ontario	Axes and edge tools for wood, iron, and stone.
Ahearn and Walsh	Ottawa, Ontario	Lumbermen's tools.
Robertson, Peter	Ottawa, Ontario	Lumbermen's and stone-cutters' tools.
Moore, Thomas	Cooksville, Ontario	Axe and tool handles.

Name.	Address.	Awarded for
Smith, R. H., and Co.	St. Catherine's, Ontario	Saws.
Spiller Brothers	St. John's, N.B.	Edge tools.
Foster, S. R., and Son	St. John's, N.B.	Nails, tacks, brads, &c.
Pillow, Hersey, and Co.	Montreal, Quebec	Nails, tacks, brads, and horse shoes.
Starr Manufacturing Co.	Halifax, N.S.	Skates,
Gilmore, G.	Cote, Montreal	Augers, bits, &c.
Whiting, A. S., Manufacturing Co.	Oshawa, Ontario	Forks, hoes, scythes, &c.
	XVI.—*Military and Sporting Arms, Weapons, &c.*	
	No awards to Canadian Exhibitors.	
	XVII.—*Carriages, Vehicles, and Accessories.*	
Hunt, Cairns, and Co.	St. Catherine's, Ontario	Wheels and wheel stock.
Malcolm, Robert	Toronto, Ontario	Harness and saddles.
Vahey, William	Forrest, Ontario	Collars and collar-blocks.
Kew, William, and Son	Beamsville, Ontario	Dog cart sleigh.
Ledoux, B.	Montreal	Sleigh.
De Wolfe, John M.	Halifax, N.S.	Light carriages.
Borbridge, S. and H.	Ottawa, Ontario	Harness and saddles.
Conboy, Daniel	Uxbridge, Ontario	Sleigh.
	XVIII.—*Railway Plant, Rolling Stock, Engines, &c.*	
Toronto Car Wheel Co.	Toronto, Ontario	Car wheels of chilled iron.
McDougall, John, and Co.	Montreal	Car wheels of chilled iron.

LIST of AWARDS to COLONIAL EXHIBITORS—*cont.*

Name.	Address.	Awarded for
	XIX.—*Vessels and Apparatus of Transportation.*	
English, William	Peterborough, Ontario	Hunting canoe.
Herald, D.	Gore's Landing, Ontario	Hunting canoe.
Coldbrook Rolling Mill Co.	St. John, N.B.	Iron ship knees.
	XX.—*Motors, Hydraulic and Pneumatic Apparatus.*	
Jones, C. C.	Fredericton, N.B.	Barrel pump.
Wilson, Clark, and Co.	Yarmouth, N.S.	Ship pump.
Ronald, John D.	Chatham, Ontario	Steam fire-engine.
Murphy, A. A.	Montreal	Pneumatic fire extinguisher.
Webster, S.	St. Catherine's, Ontario	Oil-storing tank.
Waterous Engine Works	Brantford	Steam engines.
Cox, H. W.	Peterborough, Ontario	Rotary force-pumps.
Oakville Manufacturing Co.	Oakville, Ontario	Pumps.
Patrick, Robert	Galt, Ontario	Rotary pump.
Bustin, Robert	St. John, N.B.	Fire escape.
Dixon, Smith, and Co.	Toronto	Belting.
Barber and Harris	Meaford, Ontario	Water-wheel.
Kennedy, William, and Sons	Owen Sound, Ontario	Water-wheel.
Fleming, George, and Sons	St. John, N.B.	Oscillating engines.

Name.	Address.	Awarded for
Bowes and Son	Stratford, Ontario	Force pumps.
Barns, C.	Lockville, N.B.	Rotary pumps.
Ritchie, John, and Son	Toronto, Ontario	Cocks, valves, and lubricators.
Morrison, James	Toronto, Ontario	Steam vacuum hydraulic gauges.
Brush, George	Montreal	Steam-engine.
Dailey, M. E.	Ottawa, Ontario	Telescope trestles.
Small and Fisher	Woodstock, N.B.	Barrel lifter.
Thomson and Williams' Manufacturing Co.	Stratford, Ontario	Stationary engine.
Date, John	Montreal	Diving apparatus.
Goldie and McCulloch	Galt, Ontario	Turbine water-wheel and steam engine.
Tuerk, F. W.	Berlin, Ontario	Working model water-wheel.
	XXI.—*Machine Tools for Wood, Metal, and Stone.*	
Mitchell, R., and Co.	Montreal	Lead tube bending machine.
Browne and Howe	St. John, N.B.	Turning lathe.
Kennedy, W. M., and Sons	Owen Sound, Ontario	Facing and jointing machine.
Fisher, J. F., and Co.	Kinkardine, Ontario	Clipping boiler plate machine.
McKechnie and Bertram	Dundas, Ontario	Wood moulding machine.
Mitchell and Taple	Harriston, Ontario	Wood sawing machine.
Smith, R. H., and Co.	St. Catharine's	Circular saws.
Waterous Engine Works Co.	Brantford, Ontario	Portable saw mill.
	XXII.—*Machines and Apparatus used in Sewing, &c.*	
Wilkie and Osborn	Guelph, Ontario	Sewing-machine treadle.
Wanzer, R. M., and Co.	Hamilton, Ontario	Lock-stitch sewing machine.

Name.	Address.	Awarded for
	XXIII.—*Agricultural Machines, Implements of Agriculture &c.*	
Maxwell, David	Paris, Ontario	Power chaff cutter.
Massey Manufacturing Co.	-	Sharpe's patent dumping horse rake.
Sawyer, L. D., and Co.	Hamilton, Ontario	Mowers and reapers.
Grant, Peter	Clinton, Ontario	Hay fork and conveyer.
Yeandle, Thomas	Stratford, Ontario	Single plough.
Munroe and Agar	Seaforth	Common plough.
Duperrow, C.	Stratford, Ontario	Iron diagonal harrow.
Acton Ploughing Co.	Acton, Ontario	General purpose plough.
Wilson, Thomas	Ontario	Fanning mill.
Clegg, Wood, and Co.	-	Horse rake.
Haggert Brothers	Brompton, Ontario	Threshing machines and horse gear.
Bricker, Jacob	Waterloo	Little champion thresher.
Stong, Jos. E.	Ontario	Swinging farm gate.
Dennis, Rowland	London, Ontario	Combined potato digger and ridging plough.
Watson, John	Ayr, Ontario	Collection of agricultural implements.
Wilkinson, G.	Aurora, Ontario	Double plough.
Abell, John	Woodbridge, Ontario	Portable engine and thrashing machine.
Anderson, A.	Great Britain, London, Ontario	Hand chaff-cutters.
	XXIV.—*Instruments of Medicine, Surgery, &c.*	
Blackwood, R., and Co.	Montreal	Mineral waters.
Wilson, Charles	Toronto	Mineral waters.
	XXV.—*Instruments of Precision, Research, &c.*	
Dominion Organ Co.	Bowmanville, Ontario	Reed organs.
Hearne and Harrison	Montreal	Surveying instruments.
Weber and Co.	Kingston, Ontario	Square piano.

Name.	Address.	Awarded for
	XXVI.—*Architecture and Engineering.*	
Ivis, H. R., and Co.	Montreal	Mediæval wrought-iron gates, &c.
Geological Survey of Canada		Geological maps.
Foster, S. R.	St. John, New Brunswick	Automatic fire-proof shutters.
	XXVII.—*Plastic and Graphic Art.*	
Fowler, D.	Canada	Painting in water colours.
Greig, A. N.	Montreal	Imitations of wood and marble.
Notman, W.	Montreal	Photographs.
Walker, A.	Halifax, N.S.	Gilding on glass.
Booth, William J.	Toronto	Sign Painting on glass.
Spence, J. C.	Montreal	Window of stained glass.
Hovenden and Meldrum	Toronto	Painting on glass.
	XXVIII.—*Education and Science.*	
Lovel Printing and Publishing Co.	Montreal, Quebec	School and other books.
Hunter, Rose, and Co.	Toronto	Useful publications, good printing.
Loverin, Nelson, M.D.	Montreal	Loverin's historical centograph.
Canada School Apparatus Manufacturing Co.	Toronto	Laboratory and other apparatus.
May, S. P., M.D.	Toronto, Ontario	Collection of stuffed animals for teaching zoology.
Department of Public Instruction	Province of Ontario, Canada	Maps, charts, models, text books, &c.
Young Men's Christian Association of America and Canada.		Chart showing the location of agency and branches, &c.
Browne, James	Toronto, Ontario	Maps, stand and elevator.
	XXIX.—*Horticultural Appliances, &c.*	
Casci, V.	Toronto	Fruit models.
Macom, Professor	Billeville, Ontario	Herbarium.

Name.	Address.	Awarded for
	XXX.—*Horses, Mules, and Asses.*	
White, J. W.	Ontario	Horse.
Douglass, W. J.	Ontario	Horse.
Harris, William	Ontario	Carriage horses.
Kennedy, Halliburton	Ontario	Mare and horse.
Long, William	Lansing, Ontario	Coach stallion.
Fisher, David	Colburn, Ontario	Stallion.
McKenzie, William	Columbus, Ontario	Stallion.
Somerville, Andrew	Huntingdon, Ontario	Stallion.
Fisher, J. J.	Ontario	Stallion.
Gailbraith, John	Kirby, Ontario	Roadster stallion.
Gailbraith, John	Kirby, Ontario	Roadster mare.
Newhouse, William	Brompton	Roadster stallion.
Holt, Ezra	Orino, Ontario	Stallion.
Cooper, Hugh	-	Roadster stallion.
Jenkins, J. T.	Prince Edward's Island	Horse.
Clark, William	-	Horse.
Little, T. and J.	Sandhill, Ontario	Draft horse.
Long, William	Lansing, Ontario	English draft horse.
Hurdman, W.	Ottawa, Ontario	Mare.
Hurdman, W.	Ottawa, Ontario	Draft stallion.
Boag, J. and D.	Ravenshoe, Ontario	Filly.
Boag, J. and D.	Ravenshoe, Ontario	Mare.
Boag, J. and D.	Ravenshoe, Ontario	Mare.

Name.	Address.	Awarded for
Boag, J. and D.	Ravenshoe, Ontario	Draft mare.
Boag, J. and D.	Ravenshoe, Ontario	Stallion.
Boag, J. and D.	Ravenshoe, Ontario	Mare.
Jeffrey Brothers	Whitby, Ontario	Mare.
Jeffrey Brothers	Whitby, Ontario	Draft mare.
Smith, John	Raglan, Ontario	Filly.
Dodge, George	Columbus, Ontario	Mare.
Sarter, Henry	Ponsonby, Ontario	Draft mare.
Smith, John	Raglan, Ontario	Draft mare.
Hurdman, W.	Ottawa, Ontario	Draft mare.
Currie, George	Ingersoll, Ontario	Draft mare.
Currie, George	Ingersoll, Ontario	Horses.
Douglass, C. J.	Oak Ridge, Ontario	Stallion.
Mason, C. E.	Brucefield, Ontario	Stallion.
Burgess, Alexander	Weston, Ontario	Stallion.
Hick, D. R.	Mitchell, Ontario	Stallion.
Fisher, Joseph P.	Ben Miller, Ontario	Stallion.
McDonough, James	Carlow, Ontario	Mare.
Sarter, Henry	Ponsonby, Ontario	Filly.
Glenn, John	Huron County, Ontario	Draft mare.
Glenn, John	Carlow, Ontario	Draft mare.
Glenn, John	Carlow, Ontario	Filly.
Glenn, John	Carlow, Ontario	Filly.
Gerrie, William	Dundas, Ontario	Mare.
Gerrie, William	Dundas, Ontario	Heavy matched draft mares.
Dodge, George	Columbus, Ontario	Filly.
Boyd, William	Toronto, Ontario	Heavy matched draft teams.

LIST of AWARDS to COLONIAL EXHIBITORS—*cont.*

Name.	Address.	Awarded for
	XXXI.—*Cattle.*	
Boak, Thomas	Hornby, Ontario	Shorthorn bull.
Dominion of Canada	-	Herd of shorthorn cattle.
Thomson, George	Bright, Ontario	Ayrshire cow.
Hood, George	Guelph, Ontario	Hereford and Galloway cattle.
Hunter, J. and R.	Alma, Ontario	Shorthorn cattle.
Miller, W. Junr.	Atha, Ontario	Shorthorn cattle.
Satchell Brothers	Ottawa, Ontario	Shorthorn cattle.
Rudd, George	Guelph, Ontario	Devon bulls.
Russell, James	Richmond Hill, Ontario	Shorthorn cattle.
Rodden, William	Plantagenet, Ontario	Ayrshire and Jersey cattle.
Telfer, W. B.	Ponsonby, Ontario	Shorthorn cattle.
	XXXII.—*Sheep.*	
Brooks, P. and J.	Whalem, Ontario	Leicester sheep.
Dominion of Canada, Province of Ontario	-	Ram and six ewes.
Healy, James	Adelaide, Ontario	Lincoln sheep.
Hodgson, William, and Son	Myrtle, Ontario	Cotswold sheep.
Langford, Samuel	Grantham, Ontario	Lincoln sheep.
Marsh, Robert	Richmond Hill, Ontario	Southdown sheep.
	XXXIII.—*Swine.*	
Frank, A., and Sons	Cheltenham, Ontario	Suffolk swine.
Milton, Henry	Ridgetown, Ontario	Chester white sows.
Newlove, George	Mackville, Ontario	Berkshire swine.
Wright and Butterfield	Sandwich, Ontario	Suffolk and Essex swine.

Name.	Address.	Awarded for
	XXXV.—*Poultry.*	
Allen, Daniel	Galt, Ontario	Variety of fowls.
Bogue, John	London, Ontario	Variety of fowls.
Beswick, James	Toronto, Ontario	Game fowls.
Campbell, W. M.	Brooklyn, Ontario	Variety of fowls.
Cooper, H.	Hamilton, Ontario	Variety of fowls.
Doel, W. H.	Toronto, Ontario	Variety of fowls.
Forbes, William	Grimsby, Ontario	Fowls.
Hewson, W. G.	Oakville, Ontario	Fowls.
Hinman, Platt	Grafton, Ontario	Ducks.
Kay, Duncan	Galt, Ontario	Variety of fowls.
Perley and McCummings	Paris, Ontario	Game chicks.
McMillan, Richard	Galt, Ontario	Variety of fowls.
McNeil, William	London, Ontario	Polish chicks.
Pellow, Thomas	London, Ontario	Variety of fowls.
Plummer, J.	London, Ontario	Polish chicks.
Smith, W. M.	Fairfield Plains, Ontario	Variety of fowls.
Terrill, A.	Wooler, Ontario	Ducks and geese.
Thomas, H. M.	Brooklyn, Ontario	Variety of fowls.
Waddell, H. and T.	Hamilton, Ontario	Hamburghs.
Weld, John	London, Ontario	Dorking chicks.
	XXXVI.—*Pomology.*	
Newman, J. W.	Lachine, Canada	Seedling apples.
Smith, Donald	Ontario	Apples.
Dougall, James	Windsor, Ontario	Collection of apples.

LIST of AWARDS to COLONIAL EXHIBITORS—*cont.*

Name.	Address.	Awarded for
Arnold, Charles	Paris, Ontario	Collection of apples.
Fruit Growers Association	Ontario	Apples.
Scott, Hugh, junr.	London, Ontario	Apples.
Stay, James N.	Masonville, Ontario	London pippin apple.
Fruit Growers Association	Ontario	Pears.
Province of Nova Scotia		Collection of fruit.
Fruit Growers Society	Ontario	Collection of early berries and fruits.
Fruit Growers Association	Ontario	Grapes.
Morgan, J., junr.	Quebec	Collection of grapes.
Arnold, Charles	Ontario	Seedling grapes.
Pafford, Mayor	Niagara, Ontario	Exotic grapes.
Parker, Thomas H.	Woodstock, Ontario	Grapes under glass.
Young, William	Hamilton, Ontario	Salem grapes.
Taylor, W. T.	Hamilton, Ontario	Clinton grapes.
Dominion of Canada, Province of Manitoba		Esculents.
	Collective Exhibits.	
Government of Dominion of Canada		Collective exhibit.
Department of Education for the Province of Ontario.		Educational apparatus and appliances.
	XXXIV.—*Special Awards.*	
Smith, L. H.	Strathroy, Ontario	Imported English setter dog "Leicester."
Smith, L. H.	Strathroy, Ontario	Imported English setter dog "Llewellen."
Smith, L. H.	Strathroy, Ontario	Imported English setter dog "Paris."

Mention is also made in the AMERICAN REPORT of the CANADIAN RIFLE TEAM.

Major J. E. O'Reilly, Captain.
George Disher.
William Cruit.
George Murison.
A. Bell.
Captain James Adam.
Major W. H. Cotton.
Major J. M. Gibson.
Captain J. J. Mason.

Name.	Address.	Group.	Awarded for
CAPE OF GOOD HOPE.			
Barry, Arnold, and Co.	Cape Town	4	Wheat flour.
Barry, Arnold, and Co.	Cape Town	4	Wheat.
Clear, E.	Cape Town	4	Wheat flour.
Hauf, Dr.	Robertson	4	Wines and brandy.
Cloete, J. P.	Groot Constantia	4	Wines.
Green, E. K.	Cape Town	4	Wines.
Cloete, Brothers	Constantia	4	Wines.
Rosenberg, S.	Cape Town	4	Brandy.
Marais, H. H.	Cape Town	4	Brandy.
Anderson and Murison	Cape Town	4	Wines.
Van Remen, L.	High Constantia	4	Wines.
Benningfield and Son	Natal	4	Native ivory.
Myburgh, N.	Eerste River	4	Wheat.
Mossop and Garland	Cape Town	6	Tanned bark.
Stonestreet, Samuel	Kimberley Diamond Fields	1	Diamonds.
Dunn, E. J.	Cape Town	1	Geological map.
Merriman, John	Cape Town	5	Cray fish.
Barry and Herdon	-	—	Diamonds.
Bright, H. C. R.	-	1	Collection of minerals.
Colony of the Cape of Good Hope	-	9	Wools
Douglass, A.	-	23	Ostrich incubating machine.
Government of Cape of Good Hope	-	—	Collective exhibit.
CEYLON.			
Delmege, Reid, and Co.	Colombo	1	Graphite, raw and prepared.
Government of Ceylon	-	—	Collective exhibit.

List of Awards to Colonial Exhibitors—*cont.*

Name.	Address.	Group.	Awarded for
	FIJI.		
Ryder Brothers	Mango Island	8	Sea Island cotton.
	GOLD COAST COLONY.		
Government of Gold Coast Colony	-	—	Collective exhibit.
	INDIA.		
Forbes, Dr. Watson	India Museum, London	8	Vegetable fibres.
Watson and Co.	Bombay	27	Hammered work in silver and wood carvings.
Watson and Co.	Bombay	11	Gold and silver jewellery.
Murree Brewery Co.	Punjab	4	Ale.
India Museum	London	16	Collection of arms.
India Museum	London	1	Collection of minerals.
India Museum	London	4	Cereals.
India Museum	London	9	Silk and other fabrics.
Government of India	-	—	Collective exhibit.
	JAMAICA.		
Langier, F., and Co.	Kingston	4	Chocolate.
Thomson, Robert, Superintendent Government Botanical Gardens.	Kingston	4	Preserved fruit.
Thomson, Robert	Kingston	3	Essential oils.
Lascelles, M. M.	Kingston	4	Coffee.

Name.	Address.	Group.	Awarded for
Elliwitt, Ernest	Kingston	4	Coffee.
Chalmer, Francis	Kingston	4	Coffee.
MacLaverty, Mrs.	Kingston	4	Coffee.
Harrison, James	Kingston	4	Coffee.
Davidson, John	Kingston	4	Coffee.
Stephens, Dr.	Kingston	4	Coffee.
Grant, Charles	Kingston	4	Wax.
Soutar and Co.	Kingston	4	Leaf tobacco and cigars.
Thompson and Weitzman	Kingston	4	Leaf tobacco.
Nash, Mrs. T.	Kingston	10	Hats and flower lace.
Auvrey, P. E.	Kingston	4	Wax.
Thomson, Robert	-	8	Vegetable fibres.
Thomson, Robert	-	8	Sisal hemp, China grass.
Thomson, Robert	-	6	Woods and other products.
Thomson, Robert	-	36	Tropical fruits.
Government Botanical Gardens	-	3	Raw sugar.
Jamaica Centennial Committee	-	4	Fruits.
Jamaica Commission	-	29	Economic plants.
Government of Jamaica	-	4	Coffee neramica and coffee-leaf tea.
Government of Jamaica	-	—	Collective exhibit.
McLean, John	-	4	Coffee.
Lansquinet Estate	-	4	Rum.
Hordley Estate	-	4	Rum.
New Work Estate	-	4	Rum.
Blue Castle Estate	-	4	Rum.
Amity Hall Estate	-	4	Rum.
Georgia Estate	-	4	Rum.

Name.	Address.	Group.	Awarded for
	MAURITIUS.		
Wiehé, J., Collective Exhibition	-	3	Sugar.
Horne, J., Director-General	Botanical Gardens	8	Vegetable fibres.
Government of Mauritius	-	—	Collective exhibit.
	NEW SOUTH WALES.		
New South Wales Shale and Oil Company	Sydney	1	Kerosene shale.
Moore and Co.	Sydney	1	Tin.
Dewhurst, Arthur	Tamworth	1	Tin ores.
Browne, Thomas	West Maitland	1	Sandstone.
Young, John	Sydney	1	Marbles and granite.
Hoff, C.	New Caledonia	4	Preserves.
Hoff, C.	New Caledonia	4	Canned fruits.
Hoff, C.	New Caledonia	3	Chemicals.
Biddell Brothers	Sydney	3	Confectionery.
Robertson and Co.	Botany	3	Stearine candles.
Dalton Brothers	Orange	4	Flour.
Dalton Brothers	Orange	4	Wheat.
Lewis Brothers	Tamworth	4	Flour.
Watson Brothers	Young	4	Flour.
Waters, James	Brisbanewater	4	Arrowroot.
MacArthur, Sir William	Camden	4	Maize.
Barrett and Co.	Sydney	—	Aërated waters and cordials.
Sydney Meat Preserving Company	Sydney	4	Preserved meats.
Hardie, John	Sydney	4	Biscuits and crackers.
Laurie, A. T.	Gloucester	4	Arrowroot.
Cole, W., and Son	Tomago	4	Arrowroot.
New South Wales Shale and Oil Company	Sydney	3	Mineral oil.
Barrett and Co.	Sydney	4	Syrups and extracts.

Name.	Address.	Group.	Awarded for
Schweigert, W., and Co.	Sydney	4	Cigars.
Hudson Brothers	Sydney	6	Cedar doors and table legs.
Rudder, E. W.	Kemsey	8	Fibre of gigantic nettle.
M'Caughey, Samuel	Coonong	9	Saxon merino wool.
Wilson, Alexander	Coree	9	Saxon merino wool.
King, P. G.	Goonoo Goonoo	9	Merino wool.
Clive and Hamilton	Collaroy	9	Merino wool.
Lowe, A. H.	Dynevor	9	Angora goats' wool.
Allen, John	Burrangong	9	Saxon merino wool.
Cox, F. and A.	Mudgee	9	Saxon merino wool.
Campbell, D. H.	Cunningham Plains	9	Saxon merino wool.
Brodribb, W. A.	Moolbong	9	Saxon merino wool.
Learmonth, L.	Groongal	9	Saxon merino wool.
Hume, E. B.	Burrowa	9	Saxon merino wool.
Vicars, J.	Sydney	9	Tweeds, plaids, and shawls.
Loder, A.	Colley Creek	9	Merino wool.
Lethbridge, G. L.	Singleton	9	Saxon merino wool.
Gilbert, A. N.	Warwillah	9	Saxon merino wool.
Bowman, E. and A.	Rotherwood	9	Merino wool.
Brown, T., and Co.	Tuppal	9	Merino wool.
White, F. R.	Blandford	9	Merino wool.
Bettington, J. B.	Merriewa	9	Saxon merino wool.
Cox, G. H.	Mudgee	9	Saxon merino wool.
Henty and Balfour	Albury	9	Merino wool.
Cox, E. K.	Mudgee	9	Saxon merino wool.
Tindall, E. and A.	Barragan	9	Saxon merino wool.
McVean, John	Wooloomoonoo	9	Merino wool.

LIST of AWARDS to COLONIAL EXHIBITORS—*cont.*

Name.	Address.	Group.	Awarded for
Superintendent of Destitute Children's Asylum.	Randwick	9	Silk cocoons.
Thorne, G.	Sydney	9	Silk cocoons.
Jennings, P. A.	Sydney	10	Furs.
Alderson and Sons	Sydney	12	Japanned and enamelled leather.
Wright, Davenport, and Co.	Sydney	12	Sole waxed and enamelled leather.
Richards, Thomas	Sydney	13	Printing, ruling, and binding.
Guerin, P.	Sydney	17	Saddles.
Postle, T. D.	Sydney	20	Ice maker and water cooler.
Spencer, John	Sydney	24	Mechanical dentistry.
Barnet, James	Sydney	26	Architectural designs.
Newman, J. H.	Sydney	27	Photographs.
Holtermann, B. O.	Sydney	27	Photographs.
Lindt, W. T.	Grafton	27	Photographs.
Richards, Thomas	Sydney	28	Meteorological results.
Department of Mines	Sydney	1	Mineral and geological collection. Gold and copper ores.
New South Wales Commissioners	Sydney	1	Tin ore, ingot, bar, and grain tin.
Colonial Sugar Co.	Sydney	3	Refined sugar.
Fallon, James T.	Albury	4	Wines.
Brecht, Carl, J. P.	Rosemount	4	Wines.
Munro, Alexander	Singleton	4	Wines.
Wyndham, Wadham	Bukkulla	4	Wines.
Doyle, J. F.	Kaloodah	4	Wines.
New South Wales Commissioners	Sydney	6	Woods from trees indigenous to New South Wales.
New South Wales Commissioners	Sydney	6	Barks.

Name.	Address.	Group.	Awarded for
Read, J. C., Governor of Darlinghurst Gaol.	Sydney	8	Mats and matting made by Australian aborigines.
Asylum for the Blind	-	—	Industrial work.
Butchart, J. Hawkins	Sydney	1	Collection of tin ores.
Government of New South Wales	-	—	Collective exhibit.
Lang, William	Wargam	9	Wool.
May, J. M.	-	—	Silk cocoons.
Sharkey, John	-	27	Photographs.
Surveyor-General of New South Wales	-	26	Maps of New South Wales.

Special Awards.—New South Wales Rifle Team.

Hon. Augustus Morris, Captain.	J. J. Slade.	J. S. Lynch.
Captain J. McGarvie Smith.	Daniel Gee.	

NEW ZEALAND.

Henderson and Farran	Wellington	4	Ale and stout.
Hector, Dr., New Zealand Commissioner	Wellington	6	Kauri gum.
Hector, Dr., Director Colonial Museum	Wellington	6	Barks for tanning.
Hector, Dr. James	Wellington	8	Vegetable fibres.
Hector, Dr. James	Wellington	28	Geological maps and reports.
Centennial Commission of New Zealand	Wellington	8	Phormium.
New Zealand Government	Wellington	28	Topographic maps and entomological collection.
New Zealand Institute	Wellington	28	Vol. I.—VII. Transactions and Proceedings.
Government of New Zealand	Wellington	26	Geological maps and charts.
Colony of New Zealand	Wellington	16	Aboriginal weapons and clothing.
Chambers, John	-	27	Photographs.

LIST of AWARDS to COLONIAL EXHIBITORS—*cont.*

Name.	Address.	Group.	Awarded for
Peter, W. S.	Canterbury	9	Merino wool.
Bealey, Samuel	Canterbury	9	Merino wool.
Hall, John	Canterbury	9	Merino wool.
Anstey, G. A.	Nelson	9	Merino wool.
Wason, J. Cathcart	Canterbury	9	Merino and Lincoln wool.
Braithwaite, A.	Wellington	9	Wool.
Rickman, A. H.	Canterbury	9	Wool.
Chinnery, Charles	Addington, Canterbury	6	Phormium fibre.
Wood, W. D.	Christchurch, Canterbury	4	Wheat.
Wilkens, Robert	Christchurch, Canterbury	4	Grass seed.
Cunningham, P., and Co.	Christchurch, Canterbury	4	Wheat.
Liardet, Hector E.	Wellington	10	Feather furs.
Banks, E. H.	Christchurch	4	Cereals.
Walker, Renwicks, and Co.	Auckland	3	Kauri gum.
Grayling, W. S.	Taranaki	3	Wood extracts.
Chambers, John	Auckland	6	Pressed ferns.
Colonial Museum	Wellington	1	Collection of minerals.
Government of New Zealand	—	—	Collective exhibit.
Smith, James	Nelson	4	Fruit wines.
	QUEENSLAND.		
The Commissioners for Queensland	—	—	Systematic arrangement of exhibits.
The Commissioners for Queensland	Brisbane	1	Gold trophy.
The Commissioners for Queensland	Brisbane	1	Coal exhibits.
Daintree, Richard	Holyrood House, Beckenham, Kent, England	27	Photographs colcured in oil.
Daintree, Richard	Holyrood House, Beckenham, Kent, England	1	Geological collections.
Ching, John	Hervey's Bay, Maryborough	3	Dugong oils and specimens.
Bailey, F. N.	Brisbane	6	Botanical collection.
Peak Downs Copper Co.	Peak Downs Mine	1	Malachite and refined copper.

List of Awards to Colonial Exhibitors—*cont.*

Name.	Address.	Group.	Awarded for
Mount Perry Copper Co.	Mount Perry District	1	Refined copper.
Bentrip Copper Co.	—	—	Refined copper.
Bulimba Tin Refining Co.	Stanthorpe	1	Refined tin.
Hume, W. C.	Brisbane	1	Tin ores.
Davenport, G. H.	Headington Mills, Darling Downs	9	Australian merino wool.
Shanahan and Jennings	Westbrook	9	Australian merino wool.
Green, C. H.	Goomburra, Darling Downs	9	Australian merino wool.
Lester, L. E.	Rosenthal	9	Australian merino wool.
Clark, George	East Talgai	9	Australian merino wool.
Parr, B. C.	Chiverton, Warwick	9	Australian merino wool.
Fisher, C. B.	Headington Hill	9	Australian merino wool.
Gore and Co.	Yandilla	9	Australian merino wool.
Marshall and Slade	Glengallan	9	Australian merino wool.
Clarke, Charles	Talgai	9	Angora goat hair.
Fenwick and Scott	Brisbane	9	Assortment of wools.
Fryar and Strachan	Loganholm	3	Sugar.
Davidson, J. F.	Mackay	3	Sugar.
McDonald, John	Government Penal Settlement	3	Sugar.
M'Donald, John	Penal Settlement	9	Silk.
Brown, A. H.	Maryborough	3	Sugar.
Lane, Henry	North Pine	4	Arrowroot.
Marks, W.	Tweed River	4	Arrowroot.
Downs, George	Darling Downs	4	Barley.
Keates, F.	Allora	4	Flour and meal.
Neden Brothers	Toowoomba	4	Flour.
Government Printing Department	Brisbane	—	Book printing and binding.
Government Lithographic Department	Brisbane	26	Maps.

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Name.	Address.	Group.	Awarded for
Mackay, Angus	Brisbane	3	Eucalyptus gums and tanning barks.
Simpson and Co.	Bon Accord	9	Wool.
Gregory, A. C.	St. John's Creek, Burnett District	1	Star regulus of antimony.
Mackay, A.	Brisbane	8	Cotton.
Sheriff of Queensland	Brisbane	17	Saddlery.
Stephens, T. B.	Brisbane	12	Leather and skins.
Chubb, C. F.	Ipswich	9	Silk.
M'Pherson, Alexander	Brisbane	4	Fibres.
Hill, Walter	Brisbane	6	Wood specimens.
O'Shannesy, P. A.	Rockhampton	6	Timbers.
Carey, C. M.	Brisbane	7	Box of Australian woods.
Bishop, Mrs.	Barcoo	1	Opals.
Baird, J. C.	Cooktown	6	Wattle bark for tanning.
Behland, J.	—	28	Case of insects, butterflies, &c.
Bentinck Tin Mining Company	—	1	Tin ore.
Boreham, J. H.	South Brisbane	4	Chutney and tomato sauce.
Bulimba Smelting Works	—	1	Tin.
Commissioners for Queensland	—	8	Vegetable fibres.
Davidson, J. E.	Mackay	4	Rum.
Queensland Government	—	8	Raw cotton.
The Colony of Queensland	—	1	Gold.
Hayes, W. H.	—	4	Candied Australian fruits.
Mackay, Angus	Brisbane	28	Works on "tropical agriculture."
Normanby Copper Mine	Mount Perry	1	Copper ores.
Government of Queensland	—	—	Collective exhibit.
Beal, James	—	13	Blank books, printing and binding.

Name.	Address.	Group.	Awarded for
	SOUTH AUSTRALIA.		
Commissioners for South Australia	Adelaide	1	Copper and copper ore.
Commissioners for South Australia	Adelaide	4	Cereals and other farm seeds.
Commissioners for South Australia	Adelaide	29	Wax models of fruit.
Commissioners for South Australia	Adelaide	4	Wine.
Crabb, R. S.	Adelaide	1	Malachites with azurite.
Coorong Oil and Coal Co.	Adelaide	1	Asphalte, called Coorongite.
Murray, John	Adelaide	9	Wool.
Price and Browne	Adelaide	9	Wool.
Macfarlane, Allan	Adelaide	9	Wool.
Hayward, Armstrong, and Co.	Adelaide	9	Wool.
Angus, John Howard	Adelaide	9	Wool.
Crozier, W.	Adelaide	9	Wool.
Keynes, Joseph	Adelaide	9	Wool.
Kemp, William	Adelaide	9	Wool.
Wurm, Frederick	Adelaide	9	Dressed sheep skins.
Steiner, Henry	Adelaide	9	Silk and cocoons.
Wendt, J. M.	Adelaide	10& 11	Jewellery.
Hardy, Thomas	Adelaide	11	Jewellery.
Wurm, Frederick	Adelaide	4	Dried fruits.
McEwen, George, and Son	Adelaide	4	Dried fruits.
Bagot, E. M.	Adelaide	4	Yarns.
Davenport, Samuel (S.A. Commissioner)	Adelaide	4	Dry extract of meat.
Davenport, Samuel (S.A. Commissioner)	Adelaide	3	Olive oil.
Gilbert, Joseph	Adelaide	4	Wine.
Hardy, Thomas	Adelaide	4	Wine.
Kelly, Dr.	Adelaide	4	Wine.

Name.	Address.	Group.	Awarded for
McEwen, George, and Son	Adelaide	4	Preserved fruits.
Ind, G. F.	Adelaide	4	Wine.
Thornber, Edward	Adelaide	4	Wine.
Holbrook, J. D.	Adelaide	4	Wine.
White, George	Adelaide	4	Wine.
Ross, R. D.	Adelaide	4	Wine.
Richmann, J. M.	Adelaide	4	Wine.
Gillard, Joseph	Adelaide	4	Wine.
Kaines, John H.	Adelaide	4	Wine.
Auld, Patrick	Adelaide	4	Wine.
Foote, Henry	Adelaide	4	Wine.
Hornabrook, C. A.	Adelaide	4	Liqueurs.
Davies, F. C.	Adelaide	4	Wine.
Baker, Isabella	Adelaide	—	Collective exhibit.
Government of South Australia		4	Wines.
Salter, W., and Son		28	Herbarium of South Australian Plants.
Schomburgh, Dr.		28	Systematic exhibit of Natural History of South Australia.
Waterhouse, Dr. F. G.			
Weight, J. W.	Adelaide	4	Wines.
STRAITS SETTLEMENTS.			
Behn, Meyer, and Co.		6	Gutta-percha.
TASMANIA.			
Shaw, Frederick	Redbanks, Swansea	9	Leicester wool.
Gibson, William Henry	Fairfield, Snake Banks	9	Merino wool.
Taylor, John	Millford, Campbell Town	9	Merino wool.

Name.	Address.	Group.	Awarded for
Gibson, William, and Son	Scone, Perth	9	Merino wool.
Wilson, George	Huntsworth and Ashgrove, Oatlands	9	Merino wool.
Gibson, James	Belle Vue, Cleveland	9	Merino wool.
Archer, William H. D.	Brickendon, Longford	9	Merino wool.
Archer, W. H. D.	Brickendon, Longford	4	Wheat.
Taylor, George	Millford, Campbell Town	9	Merino wool.
MacLanachan, Hon. James	Ballochmyle	9	Merino wool.
Sharland, William S.	Woodbridge, New Norfolk	9	Merino wool.
Ralston, John	Logan, Evandale	9	Merino wool.
Parramore, Thomas	Beaufront, Ross	9	Merino wool.
Lyell and Gowan	Australian Slate Co., Melbourne	1	School and roofing slate.
Kermoda, W. A.	Mona Vale	1	Sandstone.
Creswell, C. F.	Hobart Town	4	Cereals.
Creswell, C. F.	Hobart Town	6	Seeds of trees, flowers, and shrubs, eucalyptus globulus.
Kemp, George	Upper Bagdad	4	Wheat.
Salmon Commissioners of Tasmania		5	Brown trout.
Commissioners for Tasmania Lunatic Asylum.		3	Essential oil of blue gum.
Bidencope, J.	Hobart Town	10	Hats and caps.
Brock, J.	Campania	9	Merino wool.
Commissioners of Tasmania		1	Collection of ores and rocks.
Government of Tasmania		—	Collective exhibit.
Headlam, Charles	Egleston	9	Merino wool.
Keach, George W.	Chiswick, Ross	9	Merino wool.
Mount Bischoff Tin Mining Company	Mount Bischoff	1	Tin ores and tin in ingots.
Page, Samuel	Bellevue, Newtown	9	Merino wool.
Taylor, David	St. Johnstone's	9	Merino wool.

Name.	Address.	Group.	Awarded for
	TRINIDAD.		
Prestoe, Henry, Government Botanist	-	8	Collection of vegetable fibres.
Prestoe, Henry, Government Botanist	-	6	Collection of native woods.
Finlayson, Thomas A.	-	1	Asphalte.
Colonial Company, Limited	-	3	Sugar.
Government of Trinidad	-	—	Collective exhibit.
Dr. J. G. B. Siegert and Sons	Port of Spain	4	Angostura bitters.
	VICTORIA.		
Adams, James	Wahring	4	Wheat.
Acadia Catharine Gold Mining Co.	Sandhurst	1	Gold ores.
Alcock and Co.	Melbourne	7	Billiard table.
Apollo Stearine Candle Co.	Melbourne	3	Candles.
Ararat Flour Mill Co.	Ararat	4	Wheat.
Arnold, George, and Co.	Melbourne	9	Wool.
Armstrong, Alexander	Shelford	9	Wool.
Brasche, Charles	Sunbury	4	Australian wines.
Ballarat Woollen Co.	Ballarat	9	Tweeds, shawls, and flannels.
Ballarat Woollen Co.	Ballarat	9	Tweeds and blankets.
Bear and Ford	Seymour	4	Australian wines.
Best, Joseph	Great Western	4	Australian wines.
Bleasdale, Rev. J. L., D.D.	Melbourne	1	Collection of gems.
Bosisto, Jos., Pres. P.S. Vic.	Melbourne	3	Essential oils.
Bosisto, Jos., Pres. P.S. Vic.	Melbourne	24	Chemical and pharmaceutical preparations from the eucalyptus globulus.
Botanic Gardens, Director of	Melbourne	6	Carpological collection, woods, timbers, gums, resins, &c.
Bennett, T. K.	-	4	Preserved meats.

Name.	Address.	Group.	Awarded for
Bothwell, Wade	Melbourne	17	Harness, saddles, and stockmen's whips.
Botanic Gardens, Director of	Melbourne	8	Fibres of different trees and plants.
Botanic Gardens, Director of	Melbourne	6	Gums, resins, vegetable fat, and caoutchouc.
Bearley Brothers	Geelong	12	Sole leather.
Bright Brothers and Co.	Melbourne	1	Star antimony in ingots.
Buckley, Edward	Newbridge	4	Wheat and oats.
Borthwick, Alexander	Melbourne	3	Paints and varnishes.
Catlin, James	Runnymede	4	Wheat.
Clark, John, and Sons	Melbourne	12	Leather.
Commissioners for Victoria	Melbourne	28	Collection of books printed in Melbourne.
Commissioners for Victoria	Melbourne	1	Fac-similes of gold nuggets.
Commissioners for Victoria	Melbourne	3	Chemicals.
Commissioners for Victoria	Melbourne	29	Ferns.
Commissioners for Victoria	Melbourne	10	Furs.
Commissioners for Victoria	Melbourne	4	Flour from winter wheat.
Commissioners for Victoria	Melbourne	8	Vegetable fibres.
Comfort, Henry	Cheltenham	4	Tomato sauce.
Costerfield Gold and Antimony Co.	Melbourne	1	Antimony ores and regulus.
Crippa, Fabrizzio	Hepburn	4	Australian wines.
Croaker, Scott, and Co.	Melbourne	1	Regulus of antimony.
Cumming, T. F.	Stony Point	9	Wool.
Cuningham, Hastings, and Co.	Melbourne	9	Wool.
Danks, John	Melbourne	14	General brass foundry work.
Draper and Sons	Melbourne	7	Earth closets.
Dunckley and McBride	Melbourne	19	Sash and lathe lines.
Egli, F.	Seymour	4	Australian wines.
Elder, W. and N. G.	Rokewood	9	Wool.
Ferris, John, Government Printer	Melbourne	28	Reports, statistics.
Commissioners for Victoria	Melbourne	9	Raw wool.

List of Awards to Colonial Exhibitors—*cont.*

Name.	Address.	Group.	Awarded for
Currie, John Lang	Larra, Derimallum	9	Wool.
Commissioners for Victoria	Melbourne	36	Fruit, and fruit models.
Le Grande, A.	Melbourne	20	Patent Abyssinian tube wells with pumps, &c.
Fitts, Charles, and Sons	Melbourne	3	Animal oils.
Ford Brothers	Melbourne	10	Pith sunshades for horses.
Gaskell, Mrs.	Melbourne	29	Wax flowers.
Gilmour, Andrew	Colonisky	4	Oats.
Goldsbrough, R., and Co.	Melbourne	9	Wool.
Government of Victoria	Melbourne	26	Maps.
Government of Victoria	Melbourne	1	Collection of rocks and minerals.
Government of Victoria	—	—	Collective exhibit.
Grasse, Frederick	Strathfieldsaye	4	Australian wines.
Gray, Alexander, and Co.	Geelong	9	Tweeds, shawls, &c.
Guest, T. B. and Co.	Melbourne	4	Fancy biscuits.
Guthrie, G. D.	Epsom, Sandhurst	2	Stoneware.
Hodgson, R.	Collingwood	1	Antimony, lead, and tin.
Hogg, S. P., and Co.	Melbourne	4	Curry powder.
Hood and Co.	Melbourne	3	Essential oils and chemicals.
Johnston, J. S.	Sunbury	4	Australian wines.
Jung, Otto	Castlemaine	4	Australian wines.
Kitchen and Sons	Melbourne	3	Stearine candles.
Lands and Agriculture, Department of	Melbourne	6	Woods.
Latham, Edward	Melbourne	4	Ale and porter.
Longmire, Thomas	Smeaton	8	Flax stalks and seeds.
Lyon, George	Beechworth	4	Bogong sauce.
Mcllwraith, John	Melbourne	14	Tinned and composition gas pipe.
McNab, J.	Tabilk	4	Wheat.
McPherson, Thos., and Co.	Melbourne	8	Jute.
McEwan, James	Melbourne	7	Sideboard.

Name.	Address.	Group.	Awarded for
McKenzie, J. F., and Co.	Melbourne	4	Mustard.
McKenzie, J. F., and Co.	Melbourne	4	Mixed spices and ground cinnamon.
McKenzie, J. F., and Co.	Melbourne	4	Oatmeal, groats, &c.
Maplestone, Charles	Heidelberg	4	Australian wines.
Martin, P. J.	Melbourne	4	Ale.
Melbourne Meat Preserving Co.	Maribyrnong	4	Preserved meats, soups.
Moncrieff, John	Goulbourne River	4	Wheat.
Morrison, L. K.	Melbourne	—	Tube wells and pumps, with boring apparatus.
Murphy, Edward	Melbourne	14	Centre flowers and ventilators.
Musschialli, Louis	Melbourne	7	Pier glass and console table.
Myring, Joseph	Campbell's Creek	4	Barley.
Neill, Mrs. Bladen	Melbourne	9	Raw silk, cocoons, and silk.
O'Keefe, Andrew	Adelaide Vale	4	Wheat.
O'Reilly, Thomas	Toolamba	4	Wheat.
Penal Department, Inspector-General of	Melbourne	28	Leather and other manufactures.
Pepper, George	Melbourne	14	Ceiling and wall ventilators.
Pohl, Carl	Strathfieldsaye	4	Australian wines.
Polson, Angus	Moyston	4	Cereals.
Ramsden, Samuel	Melbourne	13	Paper.
Reed, Henry, and Co.	Melbourne	3	Vinegar.
Reed, Henry, and Co.	Melbourne	4	Raspberry vinegar and lime juice cordial.
Reed, Henry, and Co.	Melbourne	—	Lime Juice Cordial.
Richelieu, Madame F. de	Windsor	10	Flowers made from fish scales, &c.
Rosier, John	Melbourne	12	Boots and shoes.
Rossi, Thomas	Dry Diggings	4	Wheat.
Russell, Thomas	Mount Hesse	9	Wool.
Schmitt, Franz	Berwick, Melbourne	4	Australian wines.
Scott, James	Indigo	4	Wheat.
Smith, George	Ballarat	4	Wheat.

List of Awards to Colonial Exhibitors—*cont.*

Name.	Address.	Group.	Awarded for
Smith, G. S.	Wahgungah	4	Australian wines.
Smith and Son	Melbourne	4	Biscuits.
Smyth, R. Brough	Melbourne	1	Geological maps.
St. Arnaud Pastoral and Agency Society	St. Arnaud	4	Cereals.
Stevenson and Elliott	Melbourne	17	Landau.
St. Hubert's Vineyard Company	Yering	4	Australian wines.
Swallow and Ariell	-	4	Biscuits.
Stringer and Co.	Melbourne	4	Sauces and pickles.
Surveyor-Ceneral of Victoria	Melbourne	28	Maps of the Colony of Victoria.
St. John, F.	Melbourne	5	Specimens of prepared fish.
Synnot, George, and Co.	Melbourne	9	Lincoln wools.
Sumers, Charles	Melbourne	27	Medals in wax, models.
Treacy, John, and Co.	Geelong	4	Ale and stout, in bottles.
Timbell, Mrs. Ann	Collingwood	9	Raw silk, cocoons.
Timms Brothers	Mount Hesse	9	Wool.
Victoria Asylum and School for the Blind	Melbourne	28	Baskets, perambulators, &c.
Victoria Woollen Cloth Co.	Geelong	9	Woollens.
Wallis and Co.	Melbourne	12	Skins.
Warrenheip Distillery Co.	Ballarat	4	Spirits.
Western Meat Preserving Co.	Colac	4	Preserved meats, soups.
Wilson, John	Lismore	9	Wool.
Wilson, Sir Samuel	St. Kilda	9	Wool.
Wright, T. S.	Rochester	4	Wheat.
Zorn, Edward	Oakleigh	4	Tomato and Oakleigh sauce.

Mention is also made in the American Report of the Victoria Rifle Team.

Major J. T. Sleep.	Captain B. J. Wardill.
Lieut. T. T. Draper.	Captain H. J. King.

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GREAT BRITAIN AND IRELAND.

GROUP I.—MINERALS, MINING, AND METALLURGY, INCLUDING THE MACHINERY.

GEOLOGICAL SURVEY OF GREAT BRITAIN AND IRELAND.

Geological Maps.

Report.—A remarkable collection of maps and sections, illustrating the geology of Great Britain and Ireland.

HUGH CAMPBELL & SON, Newry Granite Polishing Works, Newry, Ireland.

Wrought Granite.

Report.—Commended for the good quality of the stone and the good workmanship of the articles exhibited.

PEN-YR-ORSEDD SLATE QUARRY CO. (LIMITED), Carnarvon, North Wales.

Slate.

Report.—Commended for the variety of exhibit and excellence of material.

CWMORTHIN SLATE CO. (LIMITED), Port Madoc, North Wales.

Roofing Slates.

Report.—Commended for the excellent quality of the slates exhibited.

A. MACDONALD, FIELD, & CO., Aberdeen, Scotland.

Granite Monuments.

Report.—Commended for the good quality of the stone and the workmanship of the objects exhibited.

JAMES HUNTER, Aberdeen, Scotland.

Granite Monument.

Report.—Commended for the excellence of material and good workmanship of the article exhibited.

GREAT NORTH OF SCOTLAND GRANITE CO. (LIMITED), Peterhead, Scotland.

Pedestal and Vase of Red Granite.

Report.—Commended for the excellence of material and the good workmanship of the articles exhibited.

BESSBROOK GRANITE WORKS, Bessbrook, Ireland.

Grey Granite Monuments.

Report.—Commended for the good colour, the strong and uniform texture of the stone, and the good workmanship of the monuments exhibited.

JOHN OAKEY & SONS, Wellington Emery Mills, London, England.

Emery Grain and Flour Emery.

Report.—Commended for a neat series of manufactured emery, for grains of uniform size with sharp edges, and for flour of different grades, manufactured by the exhibitor from the best quality of Grecian and Turkish emery.

THE GRAYS CHALK QUARRIES CO., Grays, Essex, England.

Chalk and Chalk Flint.

Report.—An interesting exhibit of chalk and chalk flints.

THE STAR PLATE AND UNIVERSAL POLISHING POWDER CO. (LIMITED), London, England.

Polishing Powder.

Report.—Commended for the good quality of the samples exhibited.

ROBT. DUNN & CO., St. Austell, Cornwall, England.

Clays.

Report.—An exhibit of good clays for the purposes specified.

GEO. KING HARRISON, Stourbridge, England.

Fire Clays.

Report.—An interesting series of clays, showing, among other things, but little contraction after being heated.

KAY & HILTON, Liverpool, England.

Millstones and Shelling Stones for Rice Hulling.

Report.—Commended for the size of the stones, good quality of finish, and character of material used in their manufacture.

T. HIGGIN & CO., Liverpool, England.

Table Salt.

Report.—Commended for good quality.

CHARLES CAMMELL & CO. (LIMITED), Sheffield, England.

Armour Plates.

Report.—Commended for the great excellence of manufacture, and the admirable quality of material, rendering it especially adapted for armour plating.

WILLIAM BAIRD & CO., Gartsherrie Iron Works, Coatbridge, Scotland.

Coal-cutting Machine.

Report.—Commended for the good arrangement of the machine for cutting coal by means of a series of blades applied by an endless chain, and the automatic arrangement for advancing the machine by means of a fixed point.

ASH & LACY, Birmingham, England.

Tinned Iron and Zinc Plates.

Report.—Commended for good quality.

JOHN BROWN & Co. (LIMITED), Sheffield, England.

Armour Plates.

Report.—Commended for great excellence of manufacture and admirable quality of material, rendering it especially adapted for armour plating.

SWANSEA TIN PLATE Co., Swansea (South Wales), Great Britain.

Tin Plate.

Report.—Commended for the superiority of the manufacture.

THE GOVERNOR AND COMPANY OF COPPER MINERS IN ENGLAND, London, England.

Tin Plates.

Report.—Commended for good quality and finish.

JONAS, MEYER & COLVER, Sheffield, England.

Crucible Steel for Tools.

Report.—Commended for fine quality.

THE WEST CUMBERLAND IRON AND STEEL Co., Workington, England.

Bessemer Pig Iron and Steel Products.

Report.—Commended for the excellent quality of material and the good workmanship.

HATTON SONS & Co., Bilston, England.

Tin Plates.

Report.—Commended for the superiority of the manufacture.

E. MOREWOOD & Co., Llanelly, South Wales, Great Britain.

Tin Plates.

Report.—Commended for the superiority of the manufacture.

HENRY NASH & Co., Liverpool, England.

Tin Plates.

Report.—Commended for excellent quality.

FREDERICK SMITH & Co., Halifax, England.

Steel Wire.

Report.—Commended for good quality.

WM. SMITH & SONS, Warrington, England.

Steel Wire.

Report.—Commended for good quality.

Great Britain and Ireland.

Group I.

W. D. Houghton, Warrington, England.

Steel Wire.

Report.—Commended for good quality.

Hawksworth, Ellison, & Co., Sheffield, England.

Steel.

Report.—Commended for good quality.

C. W. Siemens, London, England.

Regenerative Gas Furnace.

Report.—Commended for the improved capacity for regulating the intensity and character of the heat, accompanied by economy of fuel.

Phosphor-Bronze Company (Limited), London, England.

Phosphor-Bronze.

Report.—Commended for the good quality of the alloy and the number of applications.

Thomas Whitwell, Stockton-on-Tees, England.

Regenerative Hot Blast Stove.

Report.—Commended for durability of structure and economy of fuel when applied to iron-smelting furnaces of insufficient dimensions.

Hardy Patent Pick Company (Limited), Sheffield, England.

Patent Pick.

Report.—Commended for its great suitability to its intended object.

Holmes, Peyton, & Taylor, Southwark, London, England.

Coal and Rock Cutting Machine.

Report.—Commended for the great advantage presented by the machine in its small size and the facility with which it can be placed in coal seams of small thickness.

Group II.

Group II.—Pottery, Glass, Artificial Stone, &c.

The Patent Plumbago Crucible Co., London, England.

Assay, Dental Porcelain, Jewellers' and Chemists' Fire-clay Furnaces.

Report.—Commended for good shapes, well made, and of excellent quality.

King Brothers, Stourbridge, England.

Gas Retorts.

Report.—Commended for good quality.

Alexander Jenkinson, Edinburgh, Scotland.

Glass Table Ware and Decorative Pieces.

Report.—Commended for fine colours of old Venetian styles, for form, and general effect.

JAMES GREEN & NEPHEW, London, England.

Glass Table Ware, Dessert Pieces, and Candelabra.

Report.—Commended for excellent quality of glass, for fine cutting and engraving, for high quality of form, and for general excellence of the exhibition.

JOHN MILLAR & Co., Edinburgh, Scotland.

Glass Table Ware.

Report.—Commended for good quality of metal, for forms, and for engraving.

AIRE & CALDER GLASS BOTTLE Co., London, England.

Glass Bottles and Jars.

Report.—Commended for good quality, and suitability to purposes.

KILNER BROTHERS, London, England.

Glass Bottles and Jars.

Report.—Commended for good quality of glass, and for fitting of stoppers.

CHANCE BROTHERS & Co., Birmingham, England.

Glass Discs for Optical Purposes.

Report.—Commended for fine quality of glass.

A. B. DANIELL & SON, London, England.

Porcelain Pottery.

Report.—Commended for a very important and instructive exhibition, and for some of the wares, the excellent decorations of which have been either designed or suggested by the exhibitors.

MAW & Co., Broseley, Shropshire, England.

Tiles.

Report.—Commended for high quality of embossed and glazed encaustic tiles, and for general excellence of exhibition.

MINTON, HOLLINS, & Co., Stoke-upon-Trent, England.

Tiles.

Report.—Commended for high merit of encaustic and various mural tiles; for variety of designs and artistic work on panels.

HARPER & MOORES, Stourbridge, England.

Fire-brick for Blast Furnaces and small Assay Furnaces.

Report.—Commended as well shaped and of good quality.

GEO. KING HARRISON, Stourbridge, England.

Fire-bricks and Glass House Pot Clay; some unburnt Bricks.

Report.—The bricks are highly refractory, and the clay sustains a high heat with very slight contraction.

WOOD & IVERY, West Bromwich, Staffordshire, England.

Blue Brick and Terra-metallic Ware.

Report.—Commended for hard, solid body, well moulded and sharp.

THOMAS PEAKE, Tunstall, England.

Blue Brick and Terra-metallic Wares.

Report.—Commended for compact texture; excellent for solidity.

JOHNSON & Co., Ditchling, Sussex, England.

Architectural Terra-cotta.

Report.—Commended for good selection of designs and good modelling.

A. H. LAVERS, London, England.

Portland Cement.

Report.—The Portland cement is of good standard quality with respect to strength and hardness, and is finely ground and of good colour.

FRANCIS & Co., Cliffe Creek, Rochester, England.

Portland and Parian Cements, and Articles moulded from same.

Report.—The Portland cement is of good average quality, and the Parian cement is of superior quality. The articles moulded from the cement are strong and neatly formed, with sharp angles and edges, especially the pieces of mouldings in Parian cement.

WOULDHAM CEMENT Co., Wouldham-on-Medway, England.

Portland Cement.

Report.—The strength and hardness of the Wouldham cement place it high among Portland cements of good standard quality. The cement is heavy and of good colour, and the mortar made from it is hard, strong, and dense.

HOLLICK & Co., Greenwich, England.

Portland Cement.

Report.—The Portland cement is of excellent quality, is finely ground, and produces a mortar of great strength, hardness, and density.

W. BROWNFIELD & SON, Staffordshire, England.

Porcelain and Earthenware.

Report.—Commended for a variety of useful and decorative porcelains of high character and merit, as well as for good and serviceable earthenware.

T. C. BROWN-WESTHEAD, MOORE, & Co., Staffordshire Potteries, England.

Porcelains and Earthenware.

Report.—Commended for general good quality and integrity of the wares, and for excellent useful application to common uses.

J. STIFF & SONS, Lambeth, England.

Stoneware.

Report.—Commended for sound and hard body, and good glaze; excellent potting.

J. & C. Price & Brothers, Bristol, England.

Stoneware.

Report.—Commended for dense and strong body; forms suitable to purposes.

W. & J. A. Bailey, Alloa, Scotland.

Rockingham and Tortoise-shell Wares.

Report.—Good serviceable wares of rich and effective colours.

The Watcombe Terra-cotta Co., Watcombe, South Devon, England.

Red Terra-cotta.

Report.—Commended for successful production of decorative objects at very low prices for commercial and popular purposes.

Bates, Walker, & Co., Burslem, England.

Earthenware.

Report.—A large collection of staple and useful articles, well designed for their purposes, and very cheap.

John Edwards, Fenton, Staffordshire, England.

White Earthenware.

Report.—Commended for general good quality of wares and for good potting and fitting.

Henry Doulton & Co., Lambeth, London, England.

Terra-cotta and Decorative "Faïence" and Stoneware.

Report.—Artistic terra-cotta for decorative purposes; richly coloured ware called "Lambeth Faïence"; improved sanitary stonewares and sewer-pipes of special construction.

Doulton & Watts, Lambeth, London, England.

Stoneware, Artistic "Doulton" Wares.

Report.—Originators of a highly decorative stoneware for various artistic purposes; also excellent stoneware of large size for chemical purposes. A remarkable and instructive exhibition.

Edward Brooke & Sons, Field Lorne Fire-Clay Works, Huddersfield, Yorkshire, England.

Sanitary Tubes; Fire Bricks and Clay for Furnaces.

Report.—Commended for good material and workmanship.

Patent Selenitic Cement Co. (Limited), London, England.

Selenitic Mortar and Concrete.

Report.—The specimens are hard and strong, and the material is evidently well suited for stone or brick masonry, for stucco work, and for concrete, being nearly as strong as Portland cement mixtures containing the same proportion of sand, while it costs considerably less.

Great Britain and Ireland.

Group III.

Group III.—Chemistry and Pharmacy, including the Apparatus.

T. & H. Smith & Co., Edinburgh, Scotland.

Chemicals.

Report.—Commended for excellence of quality of chemical products (some of them first discovered by the exhibitors) extracted from vegetable and animal kingdoms, and more especially for the variety and purity of those extracted or obtained from opium, including several of great rarity not elsewhere exhibited.

T. Morson & Son, London, England.

Chemicals.

Report.—Commended for the production, in a pure state, of certain special chemicals used in pharmacy, and more especially of aconitine and its salts.

A. W. Gerrard, London, England.

Chemicals.

Report.—Commended for the production, in fine state, of certain special chemicals used in pharmacy, and especially of chrysophanic acid from gall-powder, and of pilocarpine, a new alkali first extracted by the exhibitor from jaborandi.

F. C. Calvert & Co., Bradford, near Manchester, England.

Carbolic Acid.

Report.—Commended for the production of chemically pure carbolic acid of high fusing point, also for extensive production of improved commercial carbolic and cresylic acids and of the so-called sulpho-carbolates in various forms; also for production of the carbolic acid dye products, picric acid, and aurine in a pure state.

Liver Alkali Works Co. (Limited), Liverpool, England.

Chemicals.

Report.—Commended for caustic soda, three grades.

Muspratt Brothers & Huntley, Liverpool, England.

Chemicals.

Report.—This house exhibits first-class soda products, chlorate of potash, and refined sulphur extracted from the soda residues.

James Muspratt & Sons, Liverpool, England.

Chemicals.

Report.—This house exhibits first-class soda products, chlorate of potash, and refined sulphur extracted from the soda residues.

Greenbank Alkali Co., St. Helen's, Lancashire, England.

Chemicals.

Report.—Commended for their important exhibition of chemical products with soda base, especially for their caustic soda; also for the good quality of chlorate of potash.

PETER SPENCE, Manchester, England.

Chemicals.

Report.—Commended for the excellent quality of the alum.

RICHARDS, KEARNE, & GASQUOINE, Sandbach, Cheshire, England.

Chemicals.

Report.—Commended for the good quality of the soda salts prepared by the action of ammonia on the brine from rock-salt mines.

CHANCE BROTHERS & Co., Birmingham, England.

Chemical products.

Report.—Commended for the good quality of commercial chemical products.

GASKELL, DEACON, & Co., Widnes, Lancashire, England.

Chemicals.

Report.—Commended for salts of the very first class.

RUNCORN SOAP AND ALKALI CO. (LIMITED), Liverpool, England.

Bleaching Powder and Soda Ash.

Report.—Commended for the extensive manufacture of commercial chemical products, especially bleaching powder and soda; and for the advantageous introduction of Hargreave's process for making the sulphate.

THE DESOTO ALKALI CO. (LIMITED), Widnes, Lancashire, England.

Caustic Soda.

Report.—Commended for the good quality of caustic soda and other products of chemical industry.

THOMAS JENNINGS, Cork, Ireland.

Magnesia Products.

Report.—Commended for the excellent quality of the carbonate of magnesia and calcined magnesia, partly manufactured by new methods.

THE NEWCASTLE CHEMICAL WORKS CO. (LIMITED), Newcastle-on-Tyne, England.

Soda Ashes, Alkali, and Bleaching Powder.

Report.—Commended for good and cheap products and for the introduction of the most recent apparatus and processes in the range of commercial chemical industry.

JOHN & JAMES WHITE, Shawfield Works, Glasgow, Scotland.

Bichromate of Potash.

Report.—Commended for the production of bichromate of potash, of excellent quality.

JOHN HUTCHINSON & Co., Widnes, Lancashire, England.

Chemicals.

Report.—Commended for the remarkable exhibit of chemical products, among others roll sulphur, soda residues, caustic soda, soda crystals, and bicarbonate of soda.

THOMAS HIGGIN & Co., Liverpool, England.

Salt.

Report.—Commended for excellent quality of dairy salt shown, of bright, fine grain, very pure, clean, and dry, the product of works in Cheshire, England.

JOHN CORBETT, Stoke Prior Salt Works, Worcestershire, England.

Refined Worcestershire Salt.

Report.—Commended for the excellent quality of the refined salt, serving for household and agricultural purposes.

PROF. SCHORLEMMER, Owens College, Manchester, England.

Hydro-carbons and their Compounds.

Report.—Commended as showing for the first time that the products exhibited existed ready-formed in the natural petroleums, they having previously been found only in the distillates from coal. All the compounds are chemically pure; and, while only in small quantity, still the fact of their existence is important to science, and may in the future prove of vast practical benefit. We consider the exhibit a very unique one.

J. C. & J. FIELD, London, England.

Candles, Toilet Soaps, Beeswax, and refined Yellow Wax.

Report.—Commended for the superior quality of the products, for the improvements introduced in the candle industry, and especially the introduction of ozokerite.

A. & F. PEARS, London, England.

Transparent Toilet Soap.

Report.—Commended for the excellent quality of the soaps, and for the invention of transparent soap.

PRICE'S PATENT CANDLE CO. (LIMITED), Belmont Works, Battersea, London, England.

Fatty Acids, Candles, Glycerine, Paraffine, and Tapers.

Report.—Commended for the quality and cheapness of the products.

CRAIG & ROSE, Edinburgh, Scotland.

Colours.

Report.—Commended for the important exhibit of manufactured mineral colours.

RAWLINS & SON, Prescot, England.

Ultramarines.

Report.—Commended for the fine samples of blue and green ultramarines.

GEORGE ROWNEY & Co., London, England.

Colours.

Report.—Commended for pigments remarkable for their fineness and their brilliancy, especially those intended for water-colour use.

DAVID STORER & SONS, Glasgow.

Colours.

Report.—Commended for the careful preparation of water colours.

CHARLES TURNER & SON, London, England.

Varnishes for Railway Companies, Gums, Linseed Oil, and Spirit of Turpentine.

Report.—Commended for the superior quality of the varnishes, and of the raw materials employed in their manufacture.

JOHN MACKAY, Edinburgh, Scotland.

Varnishes.

Report.—Commended for excellent quality of spirit varnishes for wood work.

MILES WILLIAMS, Wigan, Lancashire, England.

Varnish and Varnish Paints.

Report.—Commended for the good quality of varnishes.

JOHN BOND'S DAUGHTER (MRS. HICKISSON), London, England.

Marking Ink.

Report.—Commended for the superior quality and permanence of the ink.

WM. LYONS, Manchester, England.

Inks.

Report.—Commended for writing and copying inks of good quality.

HENRY CHARLES STEPHENS, London, England.

Inks.

Report.—Commended for samples attesting the quality of the inks, and particularly the coloured and copying inks. The samples of painted wood are likewise worthy of remark.

JOHN BLACKWOOD & CO., London, England.

Inks.

Report.—Commended for their inks of good quality, particularly those into the composition of which aniline and vanadic acid enter, and which serve as indelible inks for linen.

CHARLES BOWMAN, London, England.

Inks.

Report.—Commended for the good quality of their blue, red, and black marking ink (solid stencil ink).

YOUNG & STRANG, Glasgow, Scotland.

British Gum.

Report.—Commended for superior quality of artificial gums and of lactarine for the use of calico printers and finishers.

LOW, SON, & HAYDON, London, England.

Perfume Extracts and Toilet Soaps.

Report.—Commended for the excellent quality of their perfumes and soaps.

SAMUEL PERKS, Hitchin, Herts, England.

Essential Oil of Lavender, and Extract of Lavender Flowers.

Report.—Commended for the excellent quality of the products. This house makes a specialty of the manufacture of essence of lavender.

EUGENE RIMMEL, London, England.

Perfumery and Toilet Articles; Perfume Vaporisers.

Report.—Commended for the excellent quality and cheapness of his products, and the improvements introduced in the industry of perfumes.

J. & E. ATKINSON, London, England.

Perfumery and Toilet Soaps.

Report.—Commended for the superior quality of the products.

CROWN PERFUMERY CO., London, England.

Perfumes and Toilet Requisites.

Report.—Commended for the excellence of their products, and particularly for the superiority of their essences and lavender water.

MIRRLEES, TAIT, & WATSON, Glasgow, Scotland.

Sugar-making Machinery (in motion).

Report.—Commended for an important and in many respects admirable exhibit. Amongst the principal points claiming attention and deserving praise are the following: In large cane-crushing mill; judicious construction of ribbed tubular arms and rim of large spur wheel; breadth and truth of bearing of teeth of heavy gearing; position of lower rollers to prevent choking and diminish lateral strain on cheeks; detached cheek-pieces to allow of horizontal removal of lower rollers; attachment of scraping blade to movable cheek-piece instead of to main frame, thus preserving close bearing of edge to roller even under heavy strain. In small cane-crushing mill, great compactness, simplicity, and cheapness. In centrifugal hydro-extractors (large and small), the replacement of double fixed bearings by a special form of single bearing, admitting a small amount of play of the axis, and producing rotation about centre of gravity of basket, even though unequally charged round its circumference; also the ease and smoothness of starting due to peculiar form of fast and loose pulley arm used. In vacuum pump, the absence of piston packing, and peculiar disposition of valves which enables the pump to draw both air and water (no Torricellian tube needed), while the piston is in contact with water only.

FREDERICK ALLEN & SONS, London, England.

Bonbons of Sugar.

Report.—Commended for the exhibition of a varied collection of nicely prepared bonbons and lozenges, in excellent condition.

LUKE COLLIER, Rochdale, England.

Confectioners' Machine Tools.

Report.—Commended for the simplicity of construction and solidity of workmanship of machines for forming boiled sugar into variously shaped bonbons.

CROSSE & BLACKWELL, London, England.

Vinegar.

Report.—The malt vinegar exhibited by this firm, both brown and distilled, is of superior quality and in fine condition. It deserves particular notice, both for table use and still more for pickling, for which latter purpose it is largely employed by the exhibitors.

BRYANT & MAY, London, England.

Matches.

Report.—Commended for excellence of safety and wax matches and fuzees. The character of the wax matches is particularly commendable.

THOMAS BENNETT & SON, London, England.

Gold-beaters' Skins.

Report.—Commended for the good quality of the skins exhibited.

JOHN GREEN, London, England.

Ornamental Sheets of thin Gelatine.

Report.—Commended for good quality of coloured and printed gelatine in thin sheets for various ornamental purposes.

FREDERICK PUCKRIDGE & NEPHEW, London, England.

Gold-beaters' Skins.

Report.—Commended for the fine quality of the skins, and the extensive scale on which they are made.

BRUNNER, MOND, & Co., Northwich, Cheshire, England.

Chemicals.

Report.—Commended for excellent quality and adaptation to purpose intended.

ALLEN & HANBURYS, London, England.

Cod-liver Oil.

Report.—Cod-liver oil made in Norway, of excellent quality and purity.

GROUP IV.—ANIMAL AND VEGETABLE PRODUCTS, AND THE MACHINERY FOR THEIR PREPARATION.

WM. FIELD, Liverpool, England.

Oatmeal made from Irish Oats.

Report.—Commended for the excellent quality of the food material.

JOHN MCCANN, Drogheda, Ireland.

Oatmeal.

Report.—Commended for the excellent quality of the product and the great extent of the manufacture.

J. HUNTER & SON, Edinburgh, Scotland.

Oatmeal and Pearl Barley.

Report.—Commended for the following reasons:

1. Good quality of the stock from which the articles are produced, to wit, Scotch oats and barley.
2. Careful preparation, and good condition in which the articles are brought into market.

GEVELIN & Co., London, England.

Concentrated Food, prepared in Packets.

Report.—Commended for the following reasons: 1. Concentration of a large amount of nutritive matter in a very small compass; 2. Excellent flavour; 3. Successful preservation.

CAPTAIN WILLIAM DELF, Great Bentley, Colchester, England.

Wheat.

Report.—Commended for fine appearance and good weight.

HOOKER'S CREAM MILK Co., London, England.

Condensed Milk.

Report.—Well conserved; taste and colour very good.

KEEN, ROBINSON, BELLEVILLE, & Co., London, England.

Mustard.

Report.—Carefully prepared and put up.

CROSSE & BLACKWELL, London, England.

Pickles and Sauces.

Report.—Commended for the following reasons:

1. Most careful preparation.
2. Excellent taste.
3. Great variety.

GOODALL, BACKHOUSE, & Co., Leeds, England.

Yorkshire Relish.

Report.—Commended for good taste and careful preparation.

LEA & PERRINS, Worcester, England.

Worcestershire Sauce.

Report.—Commended for the following reasons:

1. Excellent taste.
2. Very carefully prepared.

JAMES BALL, London, England.

Sauce (Qui Hi Sauce).

Report.—It has a very good flavour, and is put up with great care and neatness.

JAMES PRATT, London, England.

Sauce (Pratt's National Sauce).

Report.—It is a good, well-flavoured mixture, prepared with care.

J. S. FRY & SONS, London and Bristol, England.

Chocolate.

Report.—A fine collection of chocolate and bonbons. Commended for remarkable taste and cheapness; high standard.

E. MENIER, London, England.

Chocolate.

Report.—Commended for the following reasons: 1, very fine preparation; 2, remarkable cheapness.

T. & H. SMITH & Co., Edinburgh, Scotland.

Essence of Coffee and Essence of Fruit.

Report.—The essence of coffee is very good, cheap, and portable.
There is a very fine and varied collection of essences of fruit, which all retain their characteristic aroma to a wonderful degree.

EVANS & STAFFORD, Leicester, England.

Cheese.

Report.—Commended for its fine texture and flavour.

GEORGE ARTER, Bristol, England.

Colouring for Cheese and Butter.

Report.—Greatly concentrated in strength, and of beautiful golden colour, with permanent retention in the manufactured products.

GEORGE ARTER, Bristol, England.

Colouring for Cheese—an Extract of Anatto.

Report.—Commended for its greatly concentrated form, and the rich, creamy appearance its use imparts to cheese.

GEORGE ARTER, Bristol, England.

Three Rennets Preserved.

Report.—Commended for their excellent state of preservation and freedom from offensive odours.

CROSSE & BLACKWELL, London, England.

Preserved Fruits.

Report.—The fruits have been prepared with great care from good materials, having a richness of taste rarely equalled.

J. E. H. Andrew, Stockport, England.

Tobacco Spinning Machine.

Report.—This machine is exceedingly ingenious in its combinations of motion adapted to the rather difficult operation of spinning leaf tobacco into beautiful rolls many feet in length and uniform in size and twist. The mechanical construction of this machine is creditable to the inventor and the mechanics who finished it. In the peculiar form of tobacco manufacturing adopted in some countries, this machine must effect a great saving of labour.

Cork Distilleries Co., Cork, Ireland.

Irish Whisky.

Report.—Very fine full flavour, and good spirit.

John Jamieson & Sons, Dublin, Ireland.

Whisky.

Report.—Very good.

Herbert Wright & Co., Moxton, near Dover, England.

Ale.

Report.—Commended for the excellent quality of their export pale ale, in every requisite of condition, brightness, and aroma.

Richardson, Earp, & Slater, Newark-upon-Trent, England.

Ale.

Report.—Commended for their A 1 ale; perfect in condition, and excellent in brightness and aroma.

Ind, Coope, & Co., Burton-on-Trent, England.

Ale.

Report.—Commended for the excellent quality of their "India Pale Ale" in every requisite of condition, brightness, taste, and aroma.

Bindley & Co., Burton-on-Trent, England.

Ale.

Report.—Commended for their mild ale, excellent in brightness, taste, aroma, and condition; and their strong ale is perfect in condition and brightness, and very good in taste and aroma.

J. Muir & Son, Edinburgh, Scotland.

Ale.

Report.—Commended for the excellent quality of their sparkling ale, in every requisite of condition, brightness, and aroma.

T. & H. Smith & Co., Edinburgh, Scotland.

Aërated Ginger Beer and Lemonade.

Report.—Commended for the following reasons:

1. Delicate and pleasant flavour.
2. Careful and successful preparation.

J. S. Sutcliffe, Bacup, Lancashire, England.

Middlings Purifier.

Report.—The machine works well, and the constant cleaning of the sieves by means of automatic brushes is efficient and specially to be commended.

RUFUS USHER, Bodicote, Oxfordshire, England.

Rhubarb.

Report.—Commended for success in cultivating rhubarb for medicinal purposes, and creating a quality that compares favourably with the best roots.

THOMAS SMITH & Co., London, England.

Ornamental Confectionery.

Report.—Commended for a superior and fine collection of gum paste vases, bouquets, wreaths, and ornaments for wedding cakes, very nicely worked. Great and elegant variety of costume mottoes.

GROUP V.—FISH AND FISH PRODUCTS, APPARATUS OF FISHING, &C.

CROSSE & BLACKWELL, London, England.

Salmon.

Report.—Commended for excellent preparation.

CHARLES E. FRYER, Whitehall, England.

Pilchards in oil.

Report.—Commended for excellence of preparation.

JAMES BUCHANAN, Glasgow, Scotland.

Fish-hooks.

Report.—Commended for excellence of make, good shape, and temper.

WILLIAM HENRY RYDER, Birmingham, England.

Fishing Reels and general fishing tackle, with Rods, &c.

Report.—Commended for general excellence with cheapness.

GROUP VI.—TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY.

THOS. BULLIVANT, London, England.

Sash Window.

Report.—Commended for the following reasons :—

1st. The method of construction does much to obviate accidents, as, instead of the weight being fastened to the sash directly by a cord as in the old style of windows, there is a metal guide-bar, which travels in a groove in the window-frame, to which the weight is attached. This is kept in place in the sash by a pin, and the sash can be removed by withdrawing the pin, leaving the guide-bar in the frame.

2d. The guide-bar having a spring-metal packing both on the outside and in the back, the sash is kept firmly in place, will not rattle, and will keep out dust and draughts.

Group VII.—Furniture, Upholstery, Wooden Ware, Baskets.

Hart, Son, Peard, & Co., London, England.

Furniture.

Report.—Commended for superior work, and for variety and excellence of design.

Leonard W. Collmann, London, England.

Furniture.

Report.—Commended for exquisite finish and workmanship, with mythological ornamentation of superb design and execution.

Peyton & Peyton, Birmingham, England.

Bedsteads.

Report.—Commended for beauty of style and finish in their manufacture, variety of patterns, prices, and sizes, for their adaptability to the different markets of the world, and for equal excellence both in the lower and higher grades of goods.

Howard & Sons, London, England.

Furniture.

Report.—Commended as a fine display in furniture, illustrating a new process of inlaying by the pressure of veneer into solid wood; designs artistic and finish excellent; upholstered work and gilding superb.

James Shoolbred & Co., London, England.

Furniture.

Report.—Furniture and appointments in different styles of six rooms, commended as massive in richness of material, artistic in details of carving, elegant in harmony of design and arrangement of colour, luxurious as well as practical in appliances for comfort, and the workmanship the best.

Collinson & Lock, London, England.

Furniture.

Report.—Commended for richness of style and material, elegance of design, and superior work; first-class in all respects.

Bradley Barnard, London, England.

Furniture.

Report.—Commended for practical utility, comfort, convenience, and safety; also for the beauty of its appointments, and for portability.

Invalid and camp tables are commended for originality and adaptability for practical uses.

Cox & Sons, London, England.

Furniture.

Report.—Commended as being first-class in all respects, especially in harmony of design; also for adaptation of art furniture and accessories to the style of architecture in building, both for churches and domestic use.

COOPER & HOLT, London, England.

Furniture.

Report.—Commended as a first-class exhibit, artistic and decorative, as well as suitable for general domestic use; very superior work.

WILLIAM SCOTT MORTON & Co., London, England.

Furniture.

Report.—Commended for elegance in combination of materials and decorations, and for being artistic in design and in detail of execution.

WRIGHT & MANSFIELD, London, England.

Furniture.

Report.—A magnificent display of unique work, in the style of the eighteenth century, mahogany and inlaid. These fine specimens of material and workmanship commend themselves to special notice.

DOULTON & WATTS, London, England.

Mantel-piece.

Report.—Commended for fair success in the introduction of faience as an art decoration in the manufacture of furniture.

HARRY HEMS, Exeter, England.

Alabaster Statue and Oaken Chest.

Report.—Commended for eminent success in reproducing an antique type of architecture in the chest; for the fidelity and solidity of the work; for chasteness of outline, beauty of carvings, and completeness of design; also for the perfection and purity of material and carefulness of finish in the sculptured figure, and excellence in all other details of ornamentation.

J. W. SINGER & SON, Frome, Somerset, England.

Church Ornaments.

Report.—Commended for work eminently praiseworthy as original and well done.

A. C. ENGERT & Co., London, England.

Gilt Mouldings.

Report.—Commended for good taste, design, and workmanship, and for low price.

FREDERICK SAGE, London, England.

Air-tight Show-case and Velvet Show-stands for Jewellers' Windows.

Report.—Commended for good workmanship and design.

NEWTON WILSON, & Co., London, England.

Washing Machine.

Report.—Commended for a washing machine constructed upon a good principle which is well adapted to answer the purposes intended; also for a wringer constructed upon the best principles.

EDWARD MATTHEWS & SON, London, England.

Memorial Brasses, Stained Glass Window, and Decorative Tiles.

Report.—Commended as an interesting and beautiful display of hand-painted tiles and mural brasses of fine workmanship and good design.

Group VIII.—Cotton, Linen, and other Fabrics, with the Machinery.

T. & D. Wilson & Co., Glasgow, Scotland.

Cotton Fabrics.

Report.—Commended for the great variety and excellent quality of the cotton fabrics, notably the Swiss mulls, Victoria lawns, and other goods of that class, as well as for the beauty and excellence of the curtain stuffs.

Neilson, Storer, & Sons, Johnstone, near Paisley, Scotland.

Knitting and Embroidery Cotton Yarn.

Report.—Commended for the peculiar softness, flexibility, evenness, fitness for their intended purposes.

John Hawkins & Sons, Manchester, England.

Bleached Shirtings.

Report.—Commended for the especial fineness, even texture, and excellent bleach of their highest grades of goods, combined with softness and purity.

Ferguson Brothers, Holme Head Works, near Carlisle, England.

Dyed Silesias, Sateens.

Report.—Commended for fineness of texture, superior colours, superb dyeing, with a finish of remarkable excellence. The harmony and blending of colours are exceedingly fine, also in great variety.

Salis Schwabe & Co., Manchester, England.

Printed Cotton Fabrics.

Report.—Commended for variety and elegance in design, colouring, and engraving in printed cotton fabrics for dresses and furniture chintzes, and madder colours of great excellence and beauty.

Jabez Johnson & Fildes, Manchester, England.

Coloured Quilts and Marseilles Vestings; Turkish Towels.

Report.—Commended for excellence in colouring, exceedingly well defined, good designs; Marseilles vestings, thoroughly well woven and coloured, fine material; Turkish towels and towelling excellent in every way. In all respects these three varieties are very superior.

Simpson & King, Manchester, England.

Printed Cotton Fabrics.

Report.—Commended for very superior excellence in design and combinations of colours on cotton fabrics for household decoration, printed in imitation of needlework as shown by the Kensington School of Design; remarkable and novel in all respects.

Frank S. Sandeman, Manhattan Works, Dundee, Scotland.

Linen and Jute Yarns and Canvas Paddings.

Report.—Commended for general good quality in yarns and canvas; novelty in imitation of human hair and pads.

GREENMOUNT SPINNING CO., Dublin, Ireland.

Linen Fabrics.

Report.—Commended for great variety and excellent quality, and adaptability to purpose, of brown and striped linen drills, awning stripes, sheetings, diapers, stair drills, towels, towelling, and horse covers.

HENRY MATIER & CO., Belfast, Ireland.

Linen Fabrics.

Report.—Commended for superior excellence and fineness of fabric, beauty of design and embroidery in linen handkerchiefs, cuffs, and collars; and also in printed linen handkerchiefs, excellence in design and printing.

JOHN S. BROWN & SONS, Belfast, Ireland.

Linen Fabrics.

Report.—Commended for superior excellence and beauty, in design and execution, in damask table linen, extraordinary fineness in diapers, handkerchiefs, and yarn, and great excellence in linen frontings and sheetings, and for general perfection of fabrics.

FENTON, CONNOR, & CO., Belfast, Ireland.

Linen Fabrics.

Report.—Commended for general excellence and variety of exhibit and superior quality of fronting linens, linen dress goods, and printed lawns.

J. N. RICHARDSON, SONS, & OWDEN, Belfast, Ireland.

Linen Fabrics.

Report.—Commended for superior excellence and beauty, in design and execution, in damask table linen; superior fineness and quality of linen frontings and handkerchiefs.

DICKSONS, FERGUSON, & CO., Belfast, Ireland.

Linen Fabrics.

Report.—Commended for superior quality of huckabacks and handkerchiefs, and general excellence and variety of articles.

ROBERT MCBRIDE & CO., Belfast, Ireland.

Cotton and mixed Cotton and Linen Goods.

Report.—Commended for neatness of design and clearness of printing on linen lawns; superior fineness, and excellence of Swiss mulls and other cotton fabrics.

YORK STREET FLAX SPINNING CO., Belfast, Ireland.

Linen Fabrics.

Report.—Commended for superior excellence of linen sheetings and fronting linens; novelty in linen brocades, skill in printed linens and general variety and excellence of fabrics.

WILLIAM LAIRD & CO. (Canmore Linen Works), Forfar, Scotland.

Linen Fabrics and Jute Goods.

Report.—Commended for general excellence and utility and great variety of fabrics in damask loom dice sheetings, ducks, towellings, osnaburgs, buckram, paddings, stair coverings, seamless bags, hessians, and horse cloths.

JOHN CLARK, JR., & Co., Glasgow, Scotland.

Sewing Cotton.

Report.—Commended for excellence in colour, quality, and finish of the six-cord sewing cotton.

JONAS BROOK & BROTHERS, Meltham Mills, Huddersfield, England.

Sewing Cotton.

Report.—Commended for variety and general excellence of crochet, embroidery, and sewing cotton.

JOHN DEWHURST & SONS, Belle Vue Mills, Skipton, England.

Sewing Cotton.

Report.—Commended for economy, adaptability, and excellent finish of the glace three-cord sewing cotton.

COX BROTHERS, Dundee, Scotland.

Jute Cords.

Report.—Dressed cords, jute yarn, carpet twist, and dyed twist. Commended for superior evenness and smoothness and excellent colour in the dyed goods.

ULLATHORNE & Co., Durham, England.

Shoe Threads.

Report.—Commended for superior quality and evenness of yarns, great variety and brilliancy of colours, great utility of the articles manufactured.

DUNBAR, MCMASTER, & Co., Gilford, Ireland.

Linen Threads, grey, bleached, and dyed.

Report.—Commended for superior excellence in quality and colours, general variety of products, novelty and specialty in flosses, splendid collection of goods in every respect.

J. & P. COATS, Paisley, Scotland.

Sewing Cotton.

Report.—Commended for the superior strength and excellent quality of spool cotton.

MARSHALL & Co., Leeds, England.

Linen sewing and other Threads.

Report.—Commended for superior excellence in quality and colour of threads; specialties and general variety of goods; a very superior collection of goods in every respect.

THOMAS HALL, Edinburgh, Scotland.

Hand-painted Cloths, in imitation of Tapestry, for Wall Decoration.

Report.—The novel application of scene decorations for domestic purposes, carried out by two very effective landscape paintings, size nine feet by six feet, painted in water-colours on jute canvas, adapted for inside walls and panels.

MICHAEL NAIRN & Co., Kirkcaldy, Scotland.

Floor Oil Cloths.

Report.—Commended for excellent workmanship and material; for tasteful designs and beautiful colours; extraordinary and unequalled size; flexibility and superior quality.

BOULINIKON FLOOR CLOTH MANUFACTURING CO. (LIMITED), Manchester, England.

Floor Cloth.

Report.—Commended for originality in material, adaptation to public wants, and fitness to the purposes intended; also for good quality, fair designs, flexibility, apparently great durability, and moderate prices.

BARLOW & JONES (LIMITED), Manchester, England.

Vestings, Marseilles Quilts, and Cretonnes.

Report.—Commended for the general excellence and variety of the goods exhibited, and for the special beauty and quality of the Marseilles quilts, which appear to us to be unequalled in style and quality.

BARNARD, BISHOP, & BARNARDS, Norwich, England.

Wire Netting.

Report.—Commended for excellence in diagonal weaving in a low-priced fabric. Principal merit, economy and adaptation to general use.

N. GREENING & SONS, Warrington, England.

Woven Wire.

Report.—Commended for excellence in material, regularity of meshes, smoothness of wire, strength of fabric; very wide in heavy wire-woven fabrics. General purposes; malt-kilns; rice and flour mills; general mining purposes.

J. B. BROWN & Co., London, England.

Galvanized Wire Netting for inclosing Poultry, Pheasants, Dogs, &c.

Report.—Commended for excellence in assortment, from four-inch to half-inch meshes, material, workmanship, economy, regularity of meshes, quality, and manner of galvanizing.

FAIRBAIRN, KENNEDY, & NAYLOR, Leeds, England.

Machinery for preparing and spinning Jute, &c.

Report.—Commended for excellence in design, arrangement, and construction of the machines, and for the quality and economy of their productions.

SAMUEL LAWSON & SONS, Hope Foundry, Leeds, England.

Machinery for cording, preparing, and spinning Jute, &c.

Report.—Commended for excellence in design, arrangement and construction, and smoothness in working of the machines, resulting in superior and economical production.

HOWARD & BULLOUGH, Accrington, England.

Carding Engine, Drawing Frame, and intermediate Roving Frame.

Report.—Commended for the very great novelty and originality of the electric stop-motion, which overcomes one of the most serious difficulties incident to the intermediate roving frame, and is also of great value as applied to the card and drawing frame, and for good workmanship and excellence of machines.

THOMAS GADD, Manchester, England.

Eight-colour Calico Printing Machine and Steam Engine; also Roller engraving Machinery.

Report.—Commended for great excellence in design, arrangement, and construction, fitness for the purposes intended, economy, and adaptation to public wants.

Great Britain and Ireland.

Group VIII.

GREENWOOD & BATLEY (Albion Works), Leeds, England.

Machine to tie in Warps for Looms.

Report.—Commended for originality of invention, of construction, and of exhibition, combined with utility, quality, skill, and superior workmanship. The object sought, to tie automatically instead of by hand, is completely achieved.

PLATT BROTHERS & Co. (Limited), Oldham, England.

Long Staple Cotton Gin.

Report.—Commended for originality of invention, perfection in construction, and adaptation to public wants in ginning of long staple cotton or "sea-island cotton." It ginned in presence of the Judges, in thirty minutes, 247½ pounds of sea-island *long* staple *seed cotton* (or equal to the capacity of about a 25-saw gin on *short* staple cotton) without injury to the lint, requiring about one half the power of the saw gin, the work being perfectly done.

E. ASHWORTH & SONS, Bolton, England.

Cotton Threads and Yarns.

Report.—A good exhibit, especially in three, six, and nine ply on spools, showing great excellence in strength and finish.

McTEAR & Co., Belfast, Ireland.

Ship Sheathing of Jute Felt in both Vegetable and Coal Tar; Boiler Felting.

Report.—Commended for good quality of material and workmanship.

Group IX.

GROUP IX.—WOOL AND SILK FABRICS, WITH THE MACHINERY.

PIM BROTHERS & Co., Dublin, Ireland.

Silk and Woven Poplins.

Report.—Black and coloured hand-woven plain silk poplins, excellent in every respect; furniture damasks of superior effect and manufacture.

CHARLES A. RICKARDS, Leeds, England.

Sewing Silk.

Report.—Sewing silk of excellent character, both as to quality, colour, and preparation.

SHELDON & FENTON, London, England.

Sewing Silks.

Report.—Sewing silks of excellent quality and brilliant colours, in a variety of shades.

WM. MILNER & SONS, Leek, Staffordshire, England.

Sewing Silks.

Report.—Sewing silks of excellent appearance for the prices quoted.

SAMUEL SALTER & Co., Trowbridge, Wilts, England.

Fancy Cassimeres.

Report.—A very handsome assortment of fancy cassimeres in novel styles and at moderate prices.

JOHN DAY & SON, Huddersfield, England.

Cheviot Coatings.

Report.—Cheviot coatings, of excellent manufacture, at small cost, and adapted for general use.

JOSEPH BUCKLEY & Co., Delph, near Manchester, England.

Cotton and Wool Shawls.

Report.—Cotton and wool shawls, in tasteful patterns and combinations at low cost.

JOHN TAYLOR & SONS, Great Britain.

Worsted Coatings and Silk and Wool Cassimeres.

Report.—Worsted coatings and fancy cassimeres of silk and wool, of excellent manufacture and neat patterns.

HARGREAVE & NUSSEYS, Leeds, England.

Worsted Coatings.

Report.—Worsted coatings, medium cloths, tweeds, and meltons; all of superior quality, excellent manufacture, and at low prices.

T. W. LITTLE & Co., Leeds, England.

Union Cloths.

Report.—Mixed union cloths, birds-eye, and tweeds, at low cost, adapted for general consumption.

WILLIAM CHILD, Huddersfield, England.

Mohair Seal-skins.

Report.—A very fine exhibit of mohair seal-skins, tipped seal and dog skins, of exceedingly fine quality, rich material and finish; all of the highest order of merit.

M. MAHONY & BROS., Cork, Ireland.

Blarney Tweeds.

Report.—A complete assortment of Blarney tweeds, in a great variety of colours, patterns, and qualities; all of a high order of merit, and most useful goods for general consumption.

HENRY ANDREWS & Co., Leeds, England.

Coatings and Cotton Warp.

Report.—Worsted coatings, cotton warp, melton, and water-proof, of excellent manufacture, and at low cost.

J. D. BIRCHALL & Co., Leeds, England.

Tweeds and Coatings.

Report.—A very complete assortment of light tweeds, of beautiful colours and texture; also worsted coatings, meltons, and beavers; all of superior merit, at moderate cost, and adapted for general use.

B. Hepworth & Sons, Dewsbury, England.

Lap Robes and Rugs.

Report.—Lap robes and rugs, in great variety of pattern and of excellent manufacture; also ingenuity of process of shearing rugs so as to produce an imitation of an animal's skin.

Norris & Co., London, England.

Upholstery Goods.

Report.—A fine display of upholstery silks, of good styles and well manufactured.

J. G. McGee & Co., Belfast, Ireland.

Rugs and Wraps.

Report.—A very handsome assortment of rugs and travelling wraps, made chiefly of mohair, silk, and wool, in imitation of real furs, otter, seal-skin, and beavers; all of superior merit and beautiful combinations.

Tomkinson & Adam, Kidderminster, England.

Carpets.

Report.—A fine collection of Axminster carpets in beautiful qualities and magnificent designs.

Henderson & Co., Durham, England.

Axminster Carpets.

Report.—A fine and rich assortment of Axminster carpets of admirable designs and qualities.

John Crossley & Sons (Limited), Halifax, England.

Carpets.

Report.—A large collection of tapestry, Brussels, velvet, and Wilton carpets, in superior qualities and at moderate prices.

John Lewis, Halifax, England.

Carpets.

Report.—A collection of Brussels and Wilton carpets of best qualities and exquisite styles.

J. & J. S. Templeton, Glasgow, Scotland.

Carpets.

Report.—Commended for a rich variety of Wilton and Brussels carpets in admirable designs and superior qualities, and especially for patent brocade curtains, silk and wool, in the most elegant designs and combinations of colours.

James Templeton & Co., Glasgow, Scotland.

Carpets.

Report.—A superior assortment of Axminster carpets, in exquisite styles and of best quality.

Thomas Stevens, Coventry, England.

Silk Loom and Silk Figured Ribbons.

Report.—Silk loom of excellent and quite original construction, design, and quality; result excellent and economical; new and excellent plan to lessen the pressure of the cards in the Jacquard machine. The large variety of figured and emblematical silk ribbons evinces the highest perfection.

FRENCH & Co., Norwich, England.

Norwich Crape, in Single, Double, and Treble.

Report.—Commended for a high degree of excellence in texture and finish.

DAVID SMITH & Co. (Limited), Halifax, England.

Prepared Shoddy and Wool.

Report.—Commended for shoddy and wool, prepared for manufacturing purposes by a patent process, by which the burrs are completely cleaned, and for cotton and wool stuff, prepared on the same principle.

THE MILL HILL WOOL AND RAG EXTRACTING Co. (Limited), Huddersfield, England.

Prepared Shoddy and Wool.

Report.—Commended for shoddy and wool, prepared for manufacturing purposes by a patent process, by which the burrs are completely cleaned, and for cotton and wool stuff, prepared on the same principle.

JAMES ODDY & SON, Bradford, England.

Wools.

Report.—A unique assortment of fleeces, admirably illustrative of the principal characteristic wools of England.

STANSFIELD, BROWN, & Co., England.

Shoe Lastings.

Report.—A superb exhibit of ten numbers of lastings, especially creditable for richness of lustre, good colour, and evenness of thread.

GREENWOOD & BATLEY, Leeds, England.

Warp-tying Machine.

Report.—A warp-tying machine of very ingenious construction.

JOHN L. BOWES & BROTHER, Liverpool, England.

Wools, Mohairs, Alpacas, Noils, and Waste.

Report.—Commended for a very complete and well-arranged assortment of wool, mohair, and alpaca, comprising about two hundred and eighty specimens, from all parts of the world; also for wool waste, extract wool, silk noils, camels'-hair noils, alpaca and mohair noils, mungo, and wool-waste, adapted for manufacturing purposes.

WM. BLISS & SON, Chipping Norton, Oxfordshire, England.

Woollens.

Report.—Commended for a very handsome assortment of Himalayan shawls, novel in pattern and combination; also, for tweeds, Cotswold suitings, serges for military wear, Cambridge rugs, Angora beavers and horse clothing; all of excellent manufacture and adapted for general use.

HOWGATES, DAY, & HOLT (Limited), Dewsbury, England.

Woollens.

Report.—A very complete assortment of reversible coatings, Victoria naps, Irish frieze, and presidents' cloth; all of excellent manufacture, at low prices.

NUSSEYS & LEACHMAN, Leeds, England.

Cloth Machine.

Report.—A powerful hot-pressing machine for cloth, having an effective and automatic action.

PRYCE JONES, Newtown, North Wales, Great Britain.

Flannels.

Report.—A creditable exhibit of white Welsh, coloured, striped, and robe flannels, together with mixed shawls of substantial make.

TITUS CALVERLEY & SONS, Huddersfield, England.

Doeskins and Cassimeres.

Report.—Commended for economy and cost in the manufacture of black doeskins and union cassimeres, which are really creditable articles at the price.

EDWARD WEBB & SONS, Worcester, England.

Hair Cloth.

Report.—Hair cloth, adapted to upholstery and tailors' padding; the former specially notable for beauty and novelty of effects in pure white grounds, with rich dark-coloured stripes in various shades; the fabric adapted to warm climates.

ROBERT S. DAVIES & SONS, Stonehouse Mills, Gloucestershire, England.

Cloths, Beavers, Meltons, and Doeskins.

Report.—A very creditable exhibit of superfine cloths, beavers, meltons, and doeskins, of excellent manufacture, colour, and finish.

KELL & Co., Bradford, England.

Lastings.

Report.—Lastings marked for their lustre and good texture.

ROBT. BREARLEY & SON, Great Britain.

Pilots, Beavers, and Overcoatings.

Report.—A very creditable exhibit of pilots, beavers, and overcoatings, at moderate cost, and adapted for general consumption.

JAMES AKED & SON, Halifax, England.

Worsted Coatings.

Report.—Worsted coatings of excellent manufacture and at low prices.

J. E. & G. F. BUCKLEY, Delph, near Manchester, England.

Shawls.

Report.—A small assortment of shawls in creditable styles and at very low cost.

ISAAC CARR & Co., Bath, England.

Meltons, Beavers, and Overcoatings.

Report.—Meltons, beavers, and overcoatings of superior manufacture and finish, at moderate cost.

THACKRAH & Co., Dewsbury, England.

Calf's Hair Coatings.

Report.—A very handsome assortment of calf's hair coatings in beautiful shades and of excellent manufacture.

AINLEY, LORD, & Co., Huddersfield, England.

Worsted Coatings.

Report.—Well-made worsted coatings of good quality.

JESSE CLEGG, Huddersfield, England.

Cotton Warp Fancy Cheviots.

Report.—Commended for economy in cost in the manufacture of cotton warp fancy cheviots of considerable merit and adaptation for general use.

LIDDELL & BRIERLY, Huddersfield, England.

Worsted Coatings.

Report.—A very creditable exhibit of worsted coatings, in neat designs, well manufactured, and adapted for general use.

STARKEY BROTHERS, Huddersfield, England.

Beavers and Doeskins.

Report.—Beavers, venetians, doeskins, and woaded cloths, of excellent manufacture, colour, and finish.

WILLIAM KING, Morley, Leeds, England.

Cotton Warp Cloths.

Report.—Commended for economy and cost of cotton warp cloths, of excellent make and finish.

CHARLES HOOPER & Co., Stonehouse, Gloucestershire, England.

Cloths, Beavers, and Doeskins.

Report.—An excellent assortment of black and blue superfine cloths; scarlet, crimson, and other fine military cloths of brilliant and permanent colours; kerseys of close and fine texture; Hooper's web, a specialty of the house; elysians, beavers, and doeskins; all of a high order of merit, and comprising an unusual variety for one manufactory.

THOMAS MALLINSON & SONS, Huddersfield, England.

Fancy Cheviots.

Report.—A small assortment of fancy cheviots of superior manufacture, at low prices, and adapted for general consumption.

MARLING & Co., Stroud, England.

Cloths and Beavers.

Report.—An excellent assortment of superfine cloths, beavers, doeskins, and cassimeres, of superior merit and of permanent colours and finish.

Group X.—Clothing, Furs, India-rubber Goods, Ornaments and Fancy Articles.

John G. McGee & Co., Belfast, Ireland.

Ulster Overcoats for Ladies and Gentlemen, Travelling and Carriage Cloaks.

Report.—Commended for originality and variety of design, skill in cut, and good taste displayed in trimmings.

I. & R. Morley, London, England.

Hosiery and Gloves.

Report.—Commended for high degree of excellence in style, colour, and ornamentation.

Smyth & Co., Dublin, Ireland.

Hosiery.

Report.—Commended for the high standard for quality in every particular.

Hitchcock, Williams, & Co., London, England.

Costumes of Mixed Fabrics for Ladies.

Report.—Commended for excellent taste in design, skill in cut, and fine workmanship.

James McLintock & Sons, Barnsley, Yorkshire, England.

Down Quilts, Skirts, Pillows, Jackets, and Dressing Gowns.

Report.—Commended for originality, utility, and fitness for the purpose intended.

Geo. Turner & Co., London, England.

Military and Travelling Equipments, Hammock and Valise.

Report.—Commended for originality, portability, and adaptation to the purpose intended.

Lincoln, Bennett, & Co., London, England.

Hats.

Report.—Commended for great variety, good taste, and moderate price.

Tress & Co., London, England.

Pith and Felt Solar Hats and Helmets.

Report.—Commended for great variety, good taste, moderate prices, and special novelty in the Indian and tropical hats.

J. & R. Morley, London, England.

Cloth, Beaver, Thread, and Cotton Gloves.

Report.—Commended for large variety, fitness, and cheapness.

Debenham & Freebody, London, England.

Gloves.

Report.—Very finely cut, sewed, and shaded in colours. Commended for fine workmanship and quality.

M. Jacoby & Co., Nottingham, England.

Valenciennes and Silk Guipures.

Report.—Valenciennes and silk guipures, imitations of Swiss curtains, lace curtains, black and coloured laces, warranted fast. Commended for good make, handsome design, and high skill in the various products.

. & E. Harding, Islington Lodge, Norfolk, England.

Embroidery.

Report.—Commended for excellent taste, skill, and workmanship.

Simon, May, & Co., Nottingham, England.

Embroidered Curtains, Mantles, and Vestibule Laces.

Report.—Embroidered curtains, mantles, and vestibule laces, of very tasteful design and superior workmanship. Also embroideries with fast warranted colours.

Working School of Village of Adare, under the Patronage of the Countess of Dunraven, Adare, County of Limerick, Ireland.

Needlework.

Report.—Commended for embroideries on lawn, executed by the members of her working school in the village of Adare, county of Limerick; well-made robes, insertions for dresses, and pin-cushion covers.

Swaine & Adeney, London, England.

Whips.

Report.—All the articles exhibited are very well made. Especial attention may be called to the whips, which are first-rate in taste, quality, and fitness. Commended for quality and fine make.

Davis & Wilson, Birmingham, England.

Mounting for Walking Sticks, Whips, and Umbrellas.

Report.—A fine set of superior mountings for walking sticks, whips, and umbrellas; perfect execution; great variety of styles; and at very moderate prices.

William Henry Martin, London, England.

Umbrellas, Walking Sticks, and Whips.

Report.—A first-rate assortment of umbrellas, walking sticks, and whips. The umbrellas especially are of the best and finest execution, and are commended as standard in quality and workmanship.

James Fenton, Birmingham, England.

Pearl Buttons.

Report.—The pearl buttons for shirts exhibited by this firm are first-rate in quality and workmanship; an excellent display.

Kirby, Beard, & Co., Birmingham, England.

Needles and Pins.

Report.—Commended for the excellent quality and fitness of the exhibited products.

HENRY MILLWARD & SONS, Redditch, England.

Needles.

Report.—All kinds of needles, and similar articles, of first-rate quality and fine workmanship.

DAVID EVANS, Redditch, England.

Needles.

Report.—Sewing needles of various sizes and kinds, including sewing-machine needles, showing the various stages of manufacture from the original steel wire to the finished product. An instructive exhibit of products of standard excellence.

JAMES SMITH & SON, Astwood Bank, near Redditch, England.

Hand-sewing Needles.

Report.—Large exhibit of hand-sewing needles, which are of excellent finish, very well tempered, and elastic, the points sharp and well tapered. Commended for quality, skill, and fitness in use.

CHARLES JEFFREYS, London, England.

Show Cases and Jewellery Boxes.

Report.—1. Dust-excluding show cases.
2. Velvet-lined and covered jewellery boxes to accompany articles sold.
3. Cases for shop display.
All of convenient and tasteful devices, admirably suited to the purposes intended.

WELSH, MARGETSON, & Co., London, England.

Scarfs and Neckties.

Report.—Commended for variety, good quality, and good work.

CROWN PERFUMERY Co., London, England.

Buffalo Horn Combs.

Report.—Commended for high degree of excellence in quality, style, and general finish.

J. JOHNSON & Co., London, England.

Shell Boxes.

Report.—A good variety of shell boxes, in a very tasteful and new style, and in the very perfect way of preparing shells. Commended for the cheapness of goods.

RICHARD HOE & SONS, London, England.

Portmanteaus, Hat-cases, and Bags.

Report.—The portmanteaus, hat-cases, and bags are very well made, in a very practical form, and good finish. Commended for substantial material and workmanship.

GEORGE BARTON KENT & Co., London, England.

Brushes and Ivory Work.

Report.—Brushes and ivory work of very fine finish, especially the hair brushes. Commended for fine workmanship and good taste.

SIMON, MAY, & Co., Nottingham, England.

Gorings, Gusseting, and Boot Webs.

Report.—Commended for a great variety of goods, of fine quality and workmanship.

THE ROYAL SCHOOL OF ART NEEDLE WORK, South Kensington, London, England.

Embroidery and Needle-work.

Report.—Commended for design and beautiful shade of colours, and for its eminent success in showing the capabilities of needle-work as a decorative art. The embroideries from classical and floral designs are admirably executed, and beautiful in effect. The whole exhibit is recognised as artistic in design and faithful in execution, noble in its object, and practical in its uses.

C. G. ELRICK, Aberdeen, Scotland.

Horn Combs.

Report.—Commended for excellence in designs, workmanship, and general finish.

GEO. JOHN SMITH, Upper Norwood, Surrey, England.

Irish Laces—Point and Limerick.

Report.—Commended for tasteful designs and excellent execution.

HAMLET NICHOLSON, Rochdale, England.

Patent Compound Cricket Balls.

Report.—Commended for fidelity in spherical shape, and for smooth and even surface.

SWAINSON, BIRLEY, & Co., London, England.

Cotton Shirtings or Long Cloth.

Report.—A good fabric, well bleached and finished.

G. P. FESTA, London, England.

Corsets.

Report.—Commended for novelty in construction and excellence in general finish.

W. S. THOMSON & SONS, London, England.

Corsets.

Report.—Commended for high degree of excellence in shape and general workmanship.

FIRMIN & SONS, London, England.

Buttons and Military Ornaments.

Report.—A large and superb display of metallic buttons for army, navy, and civic uses. Commended for excellent design and finish.

Great Britain and Ireland.

Group X.

HEYMANN & ALEXANDER, Nottingham, England.

Laces, Bobbinets, Quillings, and Curtains.

Report.—A good exhibit, displaying excellence in general finish, especially of curtains.

JOHN ENGLISH & Co., Feckenham, near Redditch, England.

Needles and Solid Head Steel Pins.

Report.—A large and complete exhibit, showing needles of superior strength and finish; solid head steel pins of excellent work and finish.

SANGSTER & Co., London, England.

Parasols and Umbrellas.

Report.—A large and varied collection of umbrellas, shades, and parasols, superb in design and excellent in construction.

Group XI. GROUP XI.—JEWELLERY, WATCH CASES, SILVER WARE, BRONZES, &c.

WILLIAM GIBSON, Belfast, Ireland.

Jewellery, Gems, and Bog-oak Articles.

Report.—An exhibition of fine jewellery and gems of high character, admirably set in special styles and with good taste; also a large variety of bog-oak articles of superior excellence.

JAMES AITCHISON, Edinburgh, Scotland.

Scotch Pebble Jewellery.

Report.—An attractive display of Scotch pebble jewellery and ornaments of marked excellence, especially in Scotch taste.

JEREMIAH GOGGIN, Dublin, Ireland.

Bog-oak Jewellery, Walking-canes, and Ornaments.

Report.—Manufactures of bog-oak, including jewellery and ornaments of this material of varied designs and superior character.

ELKINGTON & Co., Birmingham, England.

Artistic Metal Work.

Report.—Commended for their remarkable exhibit of artistic productions and effects with metals combined in incrustations and damascene work, a renewal of the higher qualities of an art of the Middle Ages, with gold and silver decorations upon the darker background of iron and steel; and for repoussé work, the famous Helicon Vase being a noble example of these combinations, and an unmatched and beautiful illustration of human genius and painstaking art work.

ELKINGTON & Co., Birmingham, England.

Enamelled Work.

Report.—Commended for their admirable specimens of enamelled objects of art, technically known as *cloisonné* and *champlevé* work. They show vases, plates, and other articles in this decorative style, which, for superiority of colour and finish, graceful detail of ornamentation, and distinctiveness of outline, place these productions among the really artistic treasures of this Exhibition.

ELKINGTON & Co., Birmingham, England.

Electro-plated Ware.

Report.—Commended for rare conceptions and designs in examples of decorative table plate, dinner and dessert services complete, and many other objects for domestic use, in electro-silver and electro-gold and oxidized silver ornamentation, with also electrotype reproductions of masterpieces shown at former Exhibitions. Commended for great mechanical excellence, original and ingenious devices, fine modelling and artistic work in the precious metals of the most distinguished character.

JOHN NEAL, London, England.

Gold Jewellery.

Report.—Commended for the solid, substantial character of the articles exhibited, in the originality and chaste elegance of their designs, in the skilful workmanship exhibited in the mounting and setting of the gems, general fine finish, and ingenuity in fabrication, necklaces being so made that they can be changed into a pair of bracelets and a brooch, and vice versâ.

GROUP XII.—LEATHER AND MANUFACTURES OF LEATHER.

WILSON, WALKER, & Co., Leeds, England.

Coloured Roans, Skivers, Morocco, Seal Skins, Calf Skins, and Russia Hides, for Shoe Work, Bookbinding, Pocket Books, Furniture, Hatters, Satchelmakers, and Fancy Goods; Chamois Skins, plain and coloured, for Domestic Uses and Fancy Goods.

Report.—We feel that we cannot too highly commend this exhibit for its extent, for the variety of kinds of goods exhibited, for the variety, perfection, and evenness of the colours, and for the variety of styles of finish, together with the excellence in each particular. The large range of work exhibited shows the most ample resources and facilities for producing all grades of fine goods in this line in the greatest perfection.

THE EDINBURGH WESTERN TANNING, CURRYING, AND JAPANNING CO. (Limited), Edinburgh, Scotland.

Leather:

Report.—The exhibit comprises fair and brown hog-skins for saddlery, japanned leather, long-grained enamelled top leather, and brown bridle leather, and evinces the most thorough workmanship and skill in preparing the hides and skins, and in tanning and finishing, all of which are done in a very superior manner.

JOHN LOBB, London, England.

Gentlemen and Ladies' Superior Hand-made Custom Boots and Shoes.

Report.—A very superior exhibit of workmanship, material, style, and proportions, consisting of gentlemen's dress, walking, shooting, fishing, hunting, and riding boots, with patent calf button gaiters, calf and grain high and strap shoes; extra stitching and workmanship very elaborate; ladies' gaiters and slippers very fine; the workmanship cannot be surpassed in any country. A portion not fresh work.

WM. ALLEN ROE, Leicester, England.

McKay Machine-sewed Men's Boots, High and Low Shoes.

Report.—A very excellent exhibit of machine-sewed work with double rows of sewing, and very substantial, material prime, consisting of extra strong shooting boots, wide welts, two rows of sewing, enamel cow hide, imitation cork sole, fair stitch on top sole; glove kid low shoe, imitation cork sole; jockey boots, and patent riding, dress, and walking boots; ladies' high leg boots; army boots, as worn by the British army; double row of sewing.

Great Britain and Ireland.

Group XII.

GREENWOOD & BATLEY, Leeds, England.

Wax Thread Lock Stitch Sewing Machine for Leather Work.

Report.—This is a sewing machine driven by power, making a lock stitch with wax thread, using two threads and working with a shuttle over the work. It is adapted for sewing the soles on boots and shoes, sewing through the outer and inner soles, or sewing the outer sole to a welt; also for sewing harness, siding up heavy boots, and for leather work generally. Its peculiar merits are the combination of a shuttle and a hook for catching and opening the loop, enabling it to use thread well waxed with ordinary shoemaker's wax; also the presser foot, which holds the leather firmly together, obviating the great strain on the needle and thread in drawing the leather together in sewing, and the general excellence and solidity of its construction.

Group XIII.

GROUP XIII.—PAPER, STATIONERY, PRINTING, AND BOOKMAKING.

CHARLES GOODALL & SON, London, England.

Playing and Christmas Cards.

Report.—Commended for a large variety of styles of decoration on the backs of his cards; all executed in good taste and design.

JEFFREY & Co., London, England.

Decorative Paper.

Report.—They exhibit several specimens of work of art in paper decoration which display the highest and purest taste. Such productions deserve special recognition, and tend to elevate paper as a decorative article.

WILLIAM LYONS, Manchester, England.

Sealing Wax.

Report.—Commended for superior quality, purity, hardness in hot climate, and freedom from blister when exposed to the sun.

ALEXANDER PIRIE & SONS, Aberdeen, Scotland.

Papers.

Report.—The writing, enamelled, rep, and other fancy papers of this celebrated house are very handsome in appearance, and are well sized.

The colours are exceptionally fine, and are not excelled by any in the Exhibition.

ROBERT FLETCHER & SON, Kersley Paper Works, Stoneclough, near Manchester, England.

White and Coloured and Tissue Paper.

Report.—This exhibit of coloured tissue and silvered papers is truly admirable and surpasses any other of its kind in the Exhibition. The paper is good, and the colours fine, varied, and remarkably well graduated. The tasteful arrangement of this display challenges the visitor's admiration.

MARCUS WARD & Co., London, England.

Stationery for the Desk, Writing Papers, and Envelopes.

Report.—Commended for the general excellence of the articles exhibited.

GREENWOOD & BATLEY, Albion Works, Leeds, England.

Job Printing Press.

Report.—Commended for general excellence as a machine for doing fine work.

The "Sun" machine is strongly built; the platten moves squarely up to the bed; there is great strength of impression, and a very large ink distribution; a combination of great utility.

WILLIAM SHAW, London, England.

Card Press.

Report.—Commended for compactness, simplicity, and great speed.

This press has an automatic feed, adjustable to any thickness of card, and prints seven thousand per hour.

All its arrangements appear to be well planned and efficient.

JOHN WALTER, London, England.

Printing Press.

Report.—This press is what is known as a web perfecting press, taking the paper from a web or roll and delivering the printed sheets. The idea of a web perfecting press is not a novel one, presses upon this principle having been projected nearly half a century since. The development of the principle is what claims attention.

It is simply and strongly constructed, with little liability to get out of order, and so arranged that the forms can be easily and quickly got ready after the last plate has been received from the stereotyper.

On the 28th of June the press was run one hour, with the following result. Prior to the commencement of the trial, the press had all the plates on but the last one and the rollers in. In three-fourths of a minute the last plate was securely put in place, and in one minute additional the first perfect sheet was delivered. The press was stopped twice to put on new rolls of paper, requiring in one case two minutes, and in the other two minutes and five seconds, and, in consequence of clogging of the sheets, the press was stopped two and one quarter minutes; total stoppage six minutes twenty-two seconds. The press printed the New York Times, and the register showed a total of ten thousand four hundred and fifty-five impressions.

The running was timed repeatedly, and found to be two hundred per minute, and for the first fifteen minutes, during which there was no stoppage, the register showed exactly three thousand impressions.

The size of the form was thirty-four and one-quarter by forty-four inches, and the web of the paper was thirty-six inches in width. Twenty copies were spoiled, and all at the time the paper jammed at the head of the delivery frame.

The papers were well printed, and the press worked very satisfactorily. At the conclusion of the trial the journals of the press were examined, and were not in the least heated. The rollers (evidently not recently made) were in good condition, and not at all softened.

GEORGE WATERSTON & SON, Edinburgh, Scotland.

Sealing Wax.

Report.—Commended for superior adhesiveness, colour, and hardness in hot climates: also for minimum waste in melting in a flame.

S. F. GRATZ, Birmingham, England.

Revolving Brass-wheel Numbering and Dating Stamps.

Report.—Commended for ingenuity, utility, and ease of manipulation. This stamp can be used for various purposes; and is so arranged as to be interchangeable, with little chance of losing the parts or disarranging them.

STEPHENSON, BLAKE, & Co., Sheffield and London, England.

Specimen Sheets of Printing Type.

Report.—Commended for great variety of "book faces," good. Old-style book face very good.

Great Britain and Ireland.

Group XIV.

Group XIV.—Apparatus for Heating, Lighting, Ventilation, Water Supply, Drainage, &c.

Mark Feetham & Co., London, England.

Grates and Fire-places.

Report.—Commended for highly artistic designs, excellence of material, very superior workmanship, combined with great practical utility.

A. M. Perkins & Son, London, England.

High-pressure Steam Baking Oven.

Report.—Commended for the following reasons:—

1. Excellence of design and workmanship, and ready adaptation to its contemplated use.
2. The facility with which the oven can be heated in a very short time to 500° Fahrenheit, and an equable temperature maintained.
3. The tubes of which (?) composed being independent of each other, should one give out, the working of the oven is not necessarily interfered with.
4. The exhibit indicates novelty and efficiency.

Robert Ulrich Etzensberger, London, England.

Apparatus for making Infusions of Coffee, Tea, &c.

Report.—Commended for the following reasons:—

1. The rapid and complete infusion in large or small quantities, without direct contact of the source of heat with the parts containing the substance or substances to be acted upon.
2. Its general adaptability to both household and public use.
3. Its compactness, ready adjustability, and design of mechanical parts as applied to the particular object of making infusions.

George Cheavin, Boston, Lincolnshire, England.

Patent Rapid Water Filters.

Report.—Commended for the following reasons:—

1. Rapidity of filtering process, especially in its application to river, rain, lake, or pond water, however foul, effectually relieving it of all impurities and organic matter.
2. Simplicity of construction.
3. Facility with which cleansed.
4. Durability.

George Jennings, Stangate, London, England.

Tip-up Wash-basin, Valve Water-closets and Traps, Kitchen and Slop Sinks, Bath-tub, Water-meters, and Water-waste Preventers.

Report.—A splendid display of goods, characterised by beauty of design, skilful workmanship, simplicity, cleanliness and durability, efficiency, and novelty of application.

Dillwyn Smith, Liverpool, England.

Apparatus for disinfecting Cabins and Holds of Ships, Wards of Hospitals, &c.

Report.—An admirable apparatus for the purpose intended.

Air-Burning Co. (Limited), Glasgow, Scotland.

Air-burning Flat-irons.

Report.—Commended for the following reasons:—

1. The peculiar mode of heating by a combination of atmospheric air with gas previous to ignition in proportions which effect complete combustion.

2. A regular steady heat is generated at any temperature.
3. The iron can be heated ready for use in two minutes.
4. The heat can be turned off or on, increased or reduced, at pleasure, the flat-iron being heated intensely is always clean, and, as no furnace is used, the ironer never requires to leave the table.
5. More work can be done in a given time by this apparatus, and at cheaper rates. The finish is superior, without the stains in ordinary ironing.

J. Gardner & Sons, London, England.

Lamps and Candlesticks.

Report.—Commended for the following reasons :—
1. Richness of finish in house-lamps in frosted and repoussé silver, nickel, and brass.
2. Students' lamps of various devices and unusual cheapness.
3. Remarkable ingenuity of device and construction in an arctic lamp, effectually arranged to prevent congelation of the oil.

Candlesticks. Commended for—1. Novel patterns of candlesticks with chimneys to prevent their being blown out, the air being supplied from the bottom. 2. Elegance of design and extreme beauty of workmanship in silver candlesticks.

Copper lanterns. Commended for good finish and design.

James Green and Nephew, London, England.

Crystal Chandeliers and Wall Candelabra.

Report.—Commended for the following reasons :—
1. This exhibit is of the highest degree of excellence in its class. The character of the material, the beauty of design, and thoroughness of construction, are quite unrivalled.
2. In wall and stand candelabra and wall lights for gas or candles, the brilliancy, whiteness, and purity of the glass are especially worthy of recognition.
3. The finish of the setting is believed to be of more than ordinary durability.

Colin Pullinger, Selsey, near Chichester, England.

Sifters, Cask Stands, and Mouse Traps.

Report.—Commended for a curious collection of very ingenious contrivances covering a wide range of objects, showing very considerable inventive skill and good workmanship.

Doulton & Co., Lambeth Pottery, London, S.E., England.

Plumbago Crucibles.

Report.—Commended for quality, finish, and variety of product adapted to the demands of the trade using them.

Steel & Garland, Wharncliffe Works, Sheffield, England.

Steel Grates and Fenders with Encaustic Tiles.

Report.—The exhibit of this house shows superior workmanship and design. Their projecting grate is well calculated to give a good result in heating.

Group XV.—Builders' Hardware, Tools, Cutlery, &c.

William Wilkinson & Sons, Sheffield, England.

Sheep Shears and Garden Shears.

Report.—Commended as of first quality and finish.

MAYER & MELTZER, London, England.

Pocket Knives, Scissors, and Razors.

Report.—Commended as of good quality and finish.

WILSON HAWKSWORTH, ELLISON, & Co., Sheffield, England.

Pocket and Table Cutlery, Scissors, Butchers' Knives, Steels, and Chisels; Manufactured Steel Files and Wire.

Report.—Commended as excellent in quality; manufactured goods well finished and of desirable description.

BROOKES & CROOKES, Sheffield, England.

Pocket Knives, Scissors, Razors, and Table Knives.

Report.—Commended as of elegant finish.

GEORGE WOSTENHOLM & SON (Limited), Sheffield, England.

Pocket Knives, Razors, and Scissors.

Report.—Commended as unsurpassed in quality, finish, and beauty of style.

J. B. ADDIS & SONS, Sheffield, England.

Carvers' Tools.

Report.—Commended as of superior finish and design.

SAMUEL CHATWOOD, London, England.

Fire and Burglar Proof Safes.

Report.—Commended as well made and of good materials.

JAMES BURNAND & Co., Sheffield, England.

Fine Cutlery, Table and Pocket Knives, and Hunting Knives.

Report.—Commended as of excellent quality and finish.

PATENT NUT AND BOLT Co., near Birmingham, England.

Bolts, Nuts, Spikes, Wrenches, Clinch Rings, and Washers.

Report.—Commended as of excellent material and workmanship.

WARD & PAYNE, Sheffield, England.

Chisels, Braces and Bits, Carvers' Tools, and Sheep Shears.

Report.—Commended as of excellent quality and well finished.

WILLIAM BAKER, London, England.

Turnscrews, Bits, and Mattress and Baling Needles.

Report.—Commended for excellent quality and good styles.

CHRISTOPHER BAKER & SONS, Birmingham, England.

Coffin Trimmings and Door Fittings.

Report.—Commended as well-finished goods.

WILLIAM SMITH & SONS, Warrington, England.

Pliers, Nippers, Vices, and Dividers.

Report.—Commended as well made and serviceable tools.

J. Neal & Co., London, England.

Patent Pyro Silver Cutlery.

Report.—Commended for the thorough incorporation of the silver with the surface of the steel without the aid of an intervening coating of copper or any other metal, thereby increasing its durability and enabling it to resist injury by sharpening, and for the elegance of their finish and handling in agate and ivory.

Colin Pullinger, Selsey, near Chichester, Sussex, England.

Self-acting Sifter, Cask Stand, and Mouse Traps.

Report.—A curious collection of very ingenious contrivances, covering a wide range of objects, showing very considerable inventive skill and good workmanship.

G. Kent, London, England.

Knife-cleaning Machines.

Report.—Commended for efficiency and adaptation to their intended purpose.

Group XVI.—Military and Sporting Arms, Weapons, &c.

P. Webley & Son, Birmingham, England.

Swinburn's Breech-loading Musket.

Report.—Commended as a good breech-loading musket, regarding the solidity of the mechanism and the disposition of the different pieces.

Alexander Henry, Edinburgh, Scotland.

Breech-loading Rifle.

Report.—Commended for the perfection and simplicity of its mechanism; and the highly efficient character of the rifling, charge, and bullet, known under the name of the "Henry system."

P. Webley & Son, Birmingham, England.

Breech-loading Sporting Arms.

Report.—Commended for good materials and workmanship in guns at low prices.

John Rigby & Co., Dublin, Ireland.

Sporting Guns and Rifles.

Report.—Commended for perfection of materials and workmanship; very superior long-range rifle.

Charles Lancaster, London, England.

Breech-loading Sporting Guns.

Report.—Commended for fine materials and unsurpassed workmanship, and especially for his "cast-off" stock for a person who has lost the right eye.

George Gibbs, Bristol, England.

Metford Patent Sporting Rifle.

Report.—Commended for excellence and finish in the manufacture of the Metford patent rifle.

William Soper, Reading, England.

Long-range Sporting Rifles.

Report.—Workmanship and materials good; absolute safety of action; easily and rapidly manipulated.

ALEXANDER HENRY, Edinburgh, Scotland.

Sporting Guns and Rifles.

Report.—Commended for very best materials and workmanship, combined with moderate prices; also for his system of rifling.

W. & C. SCOTT & SON, Premier Gun Works, Birmingham, England.

Sporting Guns.

Report.—Commended for materials and workmanship in their medium and best qualities, their "triplex action," and their "compensating lump."

ALFRED LANCASTER, London, England.

Sporting Guns.

Report.—Commended for finest materials and perfect workmanship.

JAMES PURDEY, London, England.

Sporting Guns and Express Rifles.

Report.—Commended as perfect in materials and workmanship, strong and well-proved actions.

J. LANG & SONS, London, England.

Sporting Guns and Rifles.

Report.—Commended for simplicity, strength, and thorough workmanship of their self-cocking gun.

ELEY BROTHERS, London, England.

Wadding, Shells, and Percussion Caps.

Report.—Commended as perfect in materials and workmanship.

WESTLEY RICHARDS & Co., Birmingham, England.

Hammerless Breech-loading Sporting Guns.

Report.—Commended for excellence of workmanship and novelty of design.

BICKFORD, SMITH, & Co., Tuckingmill, Cornwall, England.

Safety Fuses for Blasting Operations.

Report.—Commended for maintaining the good qualities of a valuable agent in mining industry, which was originally introduced by the exhibitors.

PIGOU, WILKS, & LAURENCE, London, England.

Gunpowder of Various Descriptions.

Report.—All the gunpowders manufactured by this firm are of excellent quality.

FIRMIN & SONS, London, England.

Dress and Service Swords.

Report.—Commended for excellence in fabrication and finish.

CAPT. EDWARD PODMORE CLARK, Bath, England.

Military Model for Illustrating and Teaching Drill Movements.

Report.—Commended for novelty, ingenuity, and fitness for the purpose intended.

Group XVII.—Carriages, Vehicles, and Accessories.

C. S. Windover, Long Acre, London, England.

Four Pleasure Carriages.

Report.—Commended for good taste in the general proportions and finish, good light workmanship. The vehicle called "Empress of Austria's Brougham" is noticeable for very complete and interesting details, such as ventilator at the top, a reading light at the back, and a ratchet latch to hold the glass up to any desired height.

McNaught & Smith, Worcester and London, England.

Four Pleasure Carriages.

Report.—Good light workmanship; graceful style; well adapted for pleasure riding.

Charles Thorn, Norwich, England.

Eight Carriages, viz., One Break, One Square Landau, One Parisian Phaeton, One Sporting Cart, One Wagonette, One Gig, One Circular Brougham, and One Victoria.

Report.—A large and very creditable exhibit. The workmanship, style, and finish of the objects shown are alike commendable. The break and wagonette deserve special notice.

Thomas Peters & Son, London, England.

Nine Carriages.

Report.—Commended for great variety of forms and patterns, sound and substantial construction. The "road drag" is especially well adapted to the purpose for which it is intended.

Hooper & Co., London, England.

Six Carriages, viz., One Landau, One C-Spring Barouche, One Park Phaeton, One Miniature Brougham, One Vienna Phaeton, One Drag.

Report.—The carriages exhibited by this firm, for correctness of outline, general form, perfect adaptation for the purposes intended, harmonious combination of colours, excellent material and workmanship, entitle them to the highest commendation; the "Vienna phaeton" and "drag" especially.

Swaine & Adeney, London, England.

Riding and Driving Whips.

Report.—Commended as very superior work, elegantly finished, and in good taste.

Haynes & Jefferis, Coventry, England.

Four Ariel Velocipedes (one of which with a Wheel Seven Feet in Diameter), One Tangent Velocipede.

Report.—Very superior work, light, and nicely constructed.

C. Digby Roberts, Coventry, England.

Two "Spider" Bicycles.

Report.—Commended for good workmanship and graceful designs.

Charles Thomson, London, England.

Three-wheel Perambulator.

Report.—A nicely made child's carriage, the strongest constructed shown at the Exhibition.

Great Britain and Ireland.

Group XVII.

DAVIS & WILSON, Birmingham, England.

Whips.

Report.—A large and very good exhibit of whips; substantial and tasteful work.

HAWKINS BROTHERS, Walsall, England.

General Saddlery Iron Work.

Report.—Very nice articles; good work, well finished, and useful.

Group XVIII.

GROUP XVIII.—RAILWAY PLANT, ROLLING STOCK AND APPARATUS, ROAD ENGINES.

SAXBY & FARMER, Kilburn, London, England.

Railway Signals, Switches, and Level Crossing Gates; Locking and Interlocking of Signals and Switches, and Locking Points.

Report.—Commended for originality, ingenious and effective arrangement of parts, and adaptability to purposes intended.

BRIERLEY, SONS, & REYNOLDS, London, England.

Railway Signals and Switches; Locking and Interlocking of Signals and Switches, and Locking the Points.

Report.—Commended for adaptability to purposes intended; improvement in locking the switch-points.

AVELING & PORTER, Rochester, Kent, England.

Traction Engine.

Report.—Commended for novelty of design; good workmanship; adaptability to purpose intended.

Group XIX.

GROUP XIX.—VESSELS AND APPARATUS OF TRANSPORTATION NOT INCLUDED IN OTHER GROUPS.

CLARK, STANDFIELD, & Co., London, England.

Model of Gridiron Floating Dock.

Report.—Commended for novelty of plan and design, and apparent commercial utility.

LIVERPOOL SPUN OAKUM Co., Liverpool, England.

Machine-spun Oakum.

Report.—Commended for superior material and manufacture.

Group XX.—Motors, Hydraulic and Pneumatic Apparatus.

Holmes, Peyton, & Taylor, London, England.

Air Compressor.

Report.—Commended for a good exhibit of a very compact air compressor.

Appleby Brothers, London, England.

Steam Cranes.

Report.—The portable steam cranes exhibited are of a high order of merit; are of a capacity of three, five, and seven tons, raised and delivered in a radius of fourteen feet. The plans provide for travel by steam or hand power.

In plans, proportions, materials, and workmanship the exhibit is first-class.

J. & H. Gwynne, Hammersmith Iron Works, London, England.

Models of Compound Surface Condensing Engines.

Report.—The pair of compound surface condensing engines with centrifugal pumps for raising large quantities of water, as presented in their well-made model, are in plan and combination of great simplicity and directness of action, and well designed for the work to be performed.

Gwynne & Co. London, England.

Centrifugal Pumps and Engines.

Report.—Commended for excellent design and workmanship, and well considered details.

Thomas Haynes & Sons, London, England.

Hydronette and Water Bringer.

Report.—The exhibit is very simple and efficient, and well adapted for the purposes intended.

J. Pickering, Globe Works, Stockton-on-Tees, England.

Pumps, Pulleys, Hoists, Steam and Water Cylinder.

Report.—The pump a good example of its class.

The pulleys simple and efficient.

T. H. P. Dennis & Co., Chelmsford, England.

Patent Full Way High Pressure Valves.

Report.—Commended for good exhibit of valves; good material and workmanship.

Frank Pearn, Manchester, England.

Steam Pump.

Report.—The pump is of substantial construction, and embodies a very valuable externally operated packing for the double-acting plunger.

Sanderson & Proctor, Huddersfield and London, England.

Automatic Fire Extinguisher and Alarm.

Report.—Commended for meritorious invention.

TANGYE BROTHERS, Cornwall Works, Birmingham, England.

Hydraulic Lifting Jacks, Screw Lifting Jacks.

Report.—Commended as a good example of plain, screw traversing, and hydraulic jacks.

ADAIR & Co., Liverpool, England.

Ship Pump.

Report.—Commended for accessibility of valves, and adaptability for use on shipboard with ordinary labour.

HIRAM CODD, London, England.

Patent Globe Stoppered Soda-Water Bottle.

Report.—A good meritorious invention.

GWYNNE & Co., London, England.

Gas Exhauster.

Report.—Commended as a reliable, compact machine, well adapted for the purpose intended; of excellent workmanship.

EDWARD GREEN & SON, Wakefield, England.

Fuel Economizer for heating the Feed Water for Steam Boilers.

Report.—They exhibit a fuel economizer to be used in connection with steam boilers. It consists in combination with a boiler of any kind, of an extensive series of vertical pipes through which the feed water passes. The surfaces of the pipes are kept free from soot by the continuous action of scrapers fitted to the surface of the pipe, operated by its own engine. The arrangements by which the plans are carried into operation are of the best character.

DILLWYN SMITH, Liverpool, England.

Automatic Stoker.

Report.—This is a most efficient attachment to a boiler furnace, feeding fine or small-sized coal regularly, and distributing it evenly, capable of any required adjustment, enabling the fires to be kept in uniform condition, and avoiding occasion for opening the doors.

LAWRENCE & Co., London, England.

Refrigerators.

Report.—Commended for simplicity and efficiency, offering a very large cooling surface, and requiring but small space.

SIEBE & GORMAN, London, England.

Diving Apparatus.

Report.—Commended for very excellent workmanship; details very carefully designed.

JOSEPH E. HOLMES, London, England.

Four-Cylinder Engine.

Report.—The four-cylinder combination presents a balanced development of power of great uniformity, through a combination of parts that provide for satisfactory operation.

DAVEY, PAXMAN, & Co., Colchester, Essex, England.

Portable Steam Engine and Vertical Boiler.

Report.—Commended for having exhibited a portable and semi-portable engine of very substantial and durable character and in a high degree fit for the purpose intended.

W. & J. GALLOWAY & SONS, Knott Mill Iron Works, Manchester, England.

Steel Boilers for Use in British Section.

Report.—Commended for having exhibited a very good steam boiler of great practical usefulness provided with the tubes called after the exhibitor; and for having contributed by the introduction of these tubes to the practical application of steam power.

JAMES J. HICKS, London, England.

Water Gauges.

Report.—Commended in that the several water gauges are in plan and workmanship of he first class, and give the water gauge an unusual value as an instrument.

JOHN MONCRIEFF, North British Glass Works, Perth, Scotland.

Gauge Glasses.

Report.—The glasses for water gauges exhibited sustain the high character of the glasses furnished by the exhibitor, having the essential quality of material required for the uses to which they are to be put.

MIRRLEES, TAIT, & WATSON, Glasgow, Scotland.

Sugar Mill and Steam Engines and Centrifugal Machines.

Report.—The engine by which the sugar mill of large size (rolls thirty-six inch diameter, seven feet long) is driven is a six-column engine using Corliss valve gear, and in the engine working the air pump a long piston having reciprocating angular motion performs the functions of valves. Both are, in plan, proportions, materials, and workmanship, of the first class, and the whole exhibit is an impressive presentation of the power of steam applied to the extraction of the juice of the sugar-cane.

WILLIAM WRIGHT, Vulcan Foundry, Coatbridge, Scotland.

Hot Water Boilers.

Report.—Commended for having exhibited a very practically arranged water boiler designed for heating dwellings, being simple in construction, offering a relatively large heating surface adapted to small rooms.

GROUP XXI.—MACHINE TOOLS FOR WOOD, METAL, AND STONE.

THOMAS GADD, Manchester, England.

Top-pressure Engraving Machine.

Report.—Commended for originality of design and excellence of construction, in a top-pressure engraving machine for transferring an engraved or other pattern from a hardened steel copy to the surface of the copper rollers used in the calico printing machine; also for originality shown in the several devices for varying the mode of action, whether by milling or compression by impact, and for the combining of the two systems in one machine.

FAIRBAIRN, KENNEDY, & NAYLOR, Leeds, England.

Quadruple Drilling Machine.

Report.—Commended for the substantial construction of a quadruple drilling machine, so arranged as to enable one man conveniently to manage four independent drills to be used for a class of articles that have to be repeated in locomotive and waggon work.

BEESLEY & SONS, Barrow in Furness, England.

Punching and Shearing Machine.

Report.—Commended for originality in the arrangement of a punching and shearing machine, whereby it is equally adapted for punching and the ordinary shear, as also for the shearing of angle bars without inconvenience.

TURNER & Co., England.

Smiths' Tools.

Report.—Commended for good quality in smiths' anvils, vices, and other tools that are used in smithies.

B. & S. MASSEY, Openshaw, Manchester, England.

Steam Hammers and Drops.

Report.—Commended for excellence and harmony in design, and for the general soundness of construction, shown in a variety of steam hammers, all admirably adapted for the different classes of work for which they are severally intended. These hammers are of all sizes, from the smallest up to five tons. These steam hammers are also distinguished for great structural solidity, and for simplicity in the motions for working the hammers, either by hand or automatically, and likewise for originality in some of the details that contribute to efficiency.

BROOKS & COOPER, Sheffield, England.

Anvils.

Report.—Commended for good sound quality and form of variously-shaped anvils used for different purposes in the practical arts.

WILLIAM ROBERTS, Bootle, near Liverpool, England.

Painting Machine for Wood Laths.

Report.—Commended for simplicity in the construction of a machine for painting laths, whereby efficiency combined with economy is effected.

JOSHUA HEAP & Co., Oldham, England.

Pipe and Bolt Screwing Machine.

Report.—Commended for good design and sound construction, in a variety of small machines that are employed for screwing pipes and other articles, whereby rapidity of execution combined with efficiency is secured; also for originality in some of the details.

PETER WRIGHT & SONS, Dudley, Worcestershire, England.

Anvils and Vices.

Report.—An exhibit of a very satisfactory collection of anvils and vices, which are commended for general excellence of design and workmanship.

GREENWOOD & BATLEY, Leeds, England.

Bolt-heading Machine.

Report.—Commended for excellence of design, and for general soundness of construction, in a machine for heading bolts, or for a variety of other work, by means of a power hammer with dies; also for originality in regard to the detail arrangements, and for convenience and efficiency.

HUGH SHEARER, London, England.

Stone-dressing Machine.—Holmes's Patent.

Report.—Commended for good design and general soundness of construction in a machine for dressing stone, which answers the purpose admirably and economically. The machine is conveniently arranged, and contains several points showing originality; and, as a whole, this machine is deserving of commendation.

ROBERT MARTIN, Old Charlton, Kent, England.

Circular Cutters.

Report.—Commended for superior workmanship in small tools of the class known as circular cutters. These tools are used in the manufacture of the multiple shearing instrument for clipping horses, and show refinement with precision.

GROUP XXII.—MACHINES, &C., USED IN SEWING AND MAKING CLOTHING.

KIMBALL & MORTON, Glasgow and Dundee, Scotland.

A large Shuttle Machine for sewing heavy Sacks, Sails, and Tarpaulins. The head in which the Needle-bar reciprocates is moved laterally after each stitch, so as to make the herring-bone stitch; the Needle-bar is operated by a rotating Shaft and Heart-cam; the feed Surface is placed above the material, and has four motions; the Shuttle is moved transversely to the direction of the feed. Also a sewing Machine having a peculiar Thread-carrying Looper attached to a Shuttle-driver and adapted to form an overseaming stitch.

Report.—Commended for quality and quantity of work done, simplicity of parts and motions, quality of workmanship and materials, and for originality.

JAMES SMITH & SON, Astwood Bank, near Redditch, England.

Needles.

Report.—A good assortment of hand and sewing-machine needles.

H. MILLWARD & SON, Redditch, England.

Needles.

Report.—The largest assortment of hand and sewing-machine needles.

KIRBY, BEARD, & Co., Birmingham and Redditch, England.

Pins, and hand and sewing-machine Needles.

Report.—A fine display of pins and of hand and sewing-machine needles.

ROBERT BELL SANSON, London, England.

A Spring-arm Band-saw Cloth-cutting Machine.

Report.—Commended for accuracy and speed of work performed.

GIMSON & COLTMAN, Leicester, England.

Knitting Machine for ribbed Fabrics.—A circular ribbing Machine for heavy work, adapted to make tubular goods with polka or plain ribbed stitch; also a knitting Machine for knitting rib tops with one or more colours.

Report.—Commended for quantity and quality of work done, quality of workmanship and materials, and originality.

Great Britain and Ireland.

JOHN WRIGHT SMITH, Leicester, England.

Knitting-machine Needles.

Group XXII.

Report.—Commended for the best assortment of knitting-machine bearded and latch needles of various sizes, grades, and gauges, and adapted to different machines.

Group XXIII.

GROUP XXIII.—AGRICULTURAL MACHINES, IMPLEMENTS OF AGRICULTURE, HORTICULTURE, AND GARDENING.

GEORGE NEIGHBOUR & SONS, London, England.

Bee-hives.

Report.—Commended for a large and varied collection of economical bee-hives, so arranged that the honey can be taken without the destruction of the bees. Special attention is directed to the unicomb hive, with Venetian blinds, to allow the bees to be exposed to light whilst the sun's rays are excluded; also to a honey extractor by centrifugal force, which removes the honey from the comb without injuring the latter, which can be returned to the hive.

WILLIAM WILKINSON & SONS, Sheffield, England.

Sheep and Hedge Shears.

Report.—Commended for thorough good material, and as well made and finished.

J. P. FISON, Feversham Works, Cambridge, England.

Safety Guard for Drum Cylinder and Small Vertical Engine.

Report.—Commended for securing safety to the feeder of a thrashing machine without in any way interfering with the work. In some measure it assists the passage of the material to be thrashed into the cylinder. The invention comprises a revolving cylinder of wood placed above and somewhat in front of the cylinder, leaving ample space for the material to be fed in between it and the feed-board. It is driven by a strap from the crank of the shaker below. Its shaft rests in a slotted bearing of the cover. In the event of any weight, such as the man's body, falling upon or against the drum guard, it is depressed, the strap is loosened, motion ceases, and the cylinder is effectually covered. The construction is simple, very little power is absorbed in working, and the cost is small. Also we recommend for favourable consideration a small vertical two-horse power portable engine of economical construction, and suitable for light work, such as chaff cutting, grinding, root cutting, &c.

JAMES FUSSELL, SONS, & Co., Frome, Somerset, England.

Scythe Blades, Reap and other Hooks, and Hay Knives.

Report.—Commended for a large exhibit of superior scythe blades, grass hooks, and hay knives, from thorough good material, uniformly made, and exhibited in a convenient form.

ARTHUR WINKLER WILLS, Park Mills, Birmingham, England.

Tools, Hoes, and Axes.

Report.—Commended for excellence of material, good and honest workmanship, and varying utility.

AVELING & PORTER, Rochester, Kent, England.

Steam Traction Road Roller.

Report.—Commended for strength, durability, efficiency, and reasonable cost. The engine loaded for work weighs ten tons, which is distributed over

a wheel surface of six feet. The front rollers, which also form the steering wheels, are forty inches (divided into two sections). The hind wheels are each sixteen inches wide, and these carry the larger portion of the weight. Were it equally divided, the average pressure would be three hundred and eleven pounds per linear inch. The principle of dividing the rolling surfaces as much as possible is of great importance in road making; since the great weight thus distributed penetrates, so to speak, beneath the surface, finds out the weak spots, and causes an even, uniform condition underneath, while the inequalities of the surface can be overcome by the addition of metal in the holes. It should be particularly noted that the formation of the wheels, larger on the inner than the outer side, tends to produce a road with a slight inclination from the centre, which is considered an important feature. The naves of the wheels are two and one-half inch cast metal. The engine is speeded to travel two miles an hour. In repairing, an old road-spike can be attached to the hind wheels, which, by tearing up the surface, greatly assist the constructor in preparing a binding surface for the new material.

BARNARD, BISHOP, & BARNARDS, Norwich, England.

Garden Furniture (in Iron).

Report.—Commended for variety, convenience, good work, and fitness for the purpose intended.

GROUP XXIV.—MEDICINE, SURGERY, PROTHESIS.

H. LEDGER & Co., London, England.

Extract of Meat.

Report.—Commended for the perfect preservation of the qualities of meat, and for its good flavour.

MAYER & MELTZER, London, England.

Surgical Instruments and Galvanic Batteries.

Report.—Commended for a large display of surgical instruments of excellent material and finish; for new instruments for the surgical treatment of the urethra; and for the practical efficiency of their galvano-caustic apparatus.

JAMES JOSEPH HICKS, London, England.

Thermometers and Urinometers.

Report.—Commended for the excellent workmanship of urinometers and thermometers. In the instruments the scale is protected by a thin layer of glass.

ALFRED WILLIAM GERRARD, London, England.

Suppositories and Mustard Plasters.

Report.—Commended for excellence of workmanship and materials.

INMAN & BROTHERS, Huddersfield, Yorkshire, England.

Aërated Medicinal Waters.

Report.—Commended for variety, perfect imitation, and beautiful preparation of aërated medicinal waters.

WILLIAM CORRY & Co., Belfast, Ireland.

Aërated Medicinal Waters.

Report.—Commended for a very fine exhibit of aërated medicinal waters, careful preparation, and imitation of the natural springs.

Great Britain and Ireland.

Group XXIV.

BEWLEY & DRAPER, Dublin, Ireland.

Ginger Ale and Lithia Waters.

Report.—Commended for general excellence, possessing in a high degree all desirable qualities.

Group XXV.

GROUP XXV.—INSTRUMENTS OF PRECISION, RESEARCH, EXPERIMENT AND ILLUSTRATION, INCLUDING TELEGRAPHY AND MUSIC.

INDIA-RUBBER, GUTTA-PERCHA, AND TELEGRAPH WORKS CO. (LIMITED), London, England.

India-rubber and Gutta-percha Goods, Telegraph Submarine Cables, and Telegraph Stores of all Descriptions.

Report.—Commended for good manufacture of india-rubber and gutta-percha goods, of insulated wire for submarine cables, torpedo telegraph cables, and subterranean telegraph cables, and of iron-sheathed insulated wire forming completed submarine cable of the several types suitable for "deep-sea," "intermediate," and "shore-end" cable. Of the excellence of one of these cables, made and laid by this Company, I* can testify from personal knowledge, having tested electrically their Direct Spanish cable during six months after its submergence, and found it perfect.

SIEMENS BROTHERS, London, England.

Submarine Telegraph Cables.

Report.—The specimens exhibited represent cables which have been made and laid by Messrs. Siemens for the River Plate and Brazil Telegraph Company, and the Direct United States Cable Company, and which are now in successful operation between Rio Janeiro, Santos, Santa Catarina, Rio Grande do Sul, and the southern frontier of Brazil, and between Ireland and the United States. As to the excellent quality of these cables, I* can testify from personal knowledge, having been one of the engineers of the River Plate and Brazil Telegraph Company, and in this capacity responsible for inspection and testing of the cables during the manufacture and laying, and having personally tested the Direct United States cable after its submergence.

TELEGRAPH CONSTRUCTION AND MAINTENANCE CO. (LIMITED), London, England.

Specimens of Submarine Telegraph Cables.

Report.—The specimens exhibited represent successful cables which have been laid by the Telegraph Construction and Maintenance Company in all parts of the world, including the Atlantic cables of 1865–66, and 1866; the cables joining England and France through the Mediterranean with Malta and Alexandria; the Red Sea and the Aden-Bombay cables, completing (with the land line over the Isthmus of Suez) the communication between England and India in one unbroken line through Gibraltar; the cables connecting India with China and Australia; and lastly, the cable connecting Australia and China. Thus, through the work of this Company, there is, at present, communication round the East between America and New Zealand. Of the electrical and mechanical excellence of several of these cables, I* can testify from personal knowledge, having been honorary consulting electrician to the Atlantic Telegraph Company, and having afterwards for a time acted on the scientific staff of the Telegraph Construction and Maintenance Company.

GILBERT L. BAUER, London, England.

One Harmonium.

Report.—Commended for its powerful yet sweet and even tone and excellent workmanship.

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* Sir William Thomson.

JNO. BRINSMEAD & SONS, London, England.

Parlour-grand and two Upright Pianos containing old system of Parallel Strings.

Report.—Commended for good quality of tone, pliable touch, and excellence of workmanship. Action shows a simplified system of escapement.

F. BESSON & Co., London, England.

Brass Musical Instruments.

Report.—Commended because the group, comprising all those used in bands, both large and small, contained instruments of the very highest finish in point of workmanship, all of ready manipulation, ease in operating, and of most satisfying purity of tone and richness and far-reaching resonance.

BOOSEY & Co., London, England.

Brass Musical Instruments.

Report.—Commended for power and good quality of tone, and fine workmanship.

THOMAS MERCER, London, England.

Marine Chronometers.

Report.—Commended for good workmanship in the manufacture of marine chronometers.

JAMES POOLE & Co., London, England.

Chronometers and Watches.

Report.—Commended for excellence of workmanship in the manufacture of marine and pocket chronometers. Two of the marine chronometers exhibited were tested by us for the adjustment of the balance for compensation for temperature, and for the rate before and after the extremes of temperature, and the adjustments were found to be excellent.

M. F. DENT, London, England.

Chronometers and Clocks.

Report.—Commended for excellence of workmanship in the manufacture of marine and pocket chronometers, and of clocks with chronometer and lever escapements; also for fine small two-day chronometers in pocket case, for exploring parties or for field use, with effective provision against over-banking.

NICOLE, NIELSEN, & Co., London, England.

Watches.

Report.—Commended for excellence of workmanship in the manufacture of pocket chronometers, and sporting, calendar, and repeating watches, and for an improved system in the construction of stem-winding watches.

CHARLES FRODSHAM & Co., London, England.

Chronometers, Clocks, and Watches.

Report.—Commended for excellence of workmanship in the manufacture of marine chronometers, watches, and clocks; for highly-finished astronomical clocks, and for a collection of compensated chronometer balances of a variety of forms for simple and auxiliary compensation. The marine and surveying chronometers were all of excellent finish, and appeared to be well sprung.

V. Kullberg, London, England.

Chronometers and Watches.

Report.—Commended for excellence of workmanship in the manufacture of marine and pocket chronometers.

J. Sewell, Liverpool, England.

Chronometers and Watches.

Report.—Commended for good workmanship in the manufacture of pocket chronometers and watches, and for the production of good marine chronometers with simple compensation, at very moderate prices.

J. J. Hicks, London, England.

Meteorological Instruments.

Report.—This exhibition consists of a very large collection of meteorological instruments, such as barometers and thermometers of all kinds; anemometers for self-recording and direct observations. These instruments are of the newest construction and well made.

Negretti & Zambra, Holborn Viaduct, London, England.

Meteorological Instruments.

Report.—Among the instruments exhibited is a very ingenious one for ascertaining the temperature of deep-sea soundings, which consists of a thermometer suspended by a horizontal axis passing through its middle, which, when the apparatus is drawn up, turns over and preserves separately the column of mercury which indicates the temperature. This arrangement is ingenious.

C. W. Siemens, London, England.

Pyrometers.

Report.—Commended for the general excellence of these instruments, devised by the inventor of the celebrated regenerative furnace.

Chance Brothers & Co., Birmingham, England.

Optical Glasses.

Report.—Commended for the superior quality and large dimensions of the discs of crown and flint glass prepared by them for telescopic objectives. In the present exhibition they have a disc of hard crown glass, remarkably free from imperfections, of twenty-four inches diameter, and pairs of flint and crown of twenty, seventeen, and twelve inches, with others smaller, of apparently equal excellence. The display is one of great interest.

Negretti & Zambra, London, England.

Microscopes.

Report.—This firm exhibits a first-class microscope-stand, and a series of objectives from three inches to one-eighth inch. The stand resembles the Ross model, so long and favourably known, possessing all the convenient mechanical contrivances for the movement of the stage in co-ordinate directions and for rotation, as well as for the adjustment of the focus by quick or slow movement, and for illumination. It is extremely stable, and, to those who do not object to a considerable weight, will be found very satisfactory. The objectives embrace a series from three inches to one-eighth inch. The high powers are formed of a simple front and three achromatic combinations. Their performance with central light is creditable, but not of the highest order. The workmanship of the first-class stand, and of the objectives, is excellent. The second-class stand is well made, but less highly finished.

Edmund Wheeler, London, England.

Preparations for the Microscope.

Report.—These objects, which are very various in character, embracing insects entire, and parts of insects, tissues vegetable and animal, mosses, algæ, sections of wood, and minerals, are put up with great neatness and evident care.

Thomas John Middleton, London, England.

Triple Lantern Dissolving View Apparatus, improved Jet for Lime Light, Colours and Materials for Painting on Glass.

Report.—The three lanterns, placed vertically one above another, afford the operator considerably increased facilities for varying the effect, while the convenience of operation is materially improved. The fronts are telescopic, and adaptable to any distance between ten and one hundred feet. The method of dissolving by alternately shutting off and turning on the gas of the different jets is attended with a sensible economy. The new lime adjusters exhibited are deserving of commendation. The workmanship of this apparatus is excellent throughout. The colours and materials for painting on glass are of noticeably good quality.

Henry Crouch, London, England.

Microscopes.

Report.—A series of microscopic stands is exhibited, all constructed upon a common plan, which combines simplicity of design with all desirable stability and remarkable lightness. The simplest form, called the educational microscope, with or without rack-work or fine lever adjustments, is believed to be the cheapest form of microscope capable of real work in the market.

The student's microscope, monocular or binocular, with rack and lever adjustments, rotating glass stage, and various appliances for aiding manipulation and illumination, possesses nearly all the advantages desirable in a microscope for investigation, and is also remarkably cheap.

The first-class microscope, monocular or binocular, embraces mechanical adjustments of the stage in co-ordinate directions, complete rotation of the stage, rack and lever adjustments, graduated limb, graduated draw-tube, improved sub-stage, and every other desirable appliance for a complete instrument, and is furnished on terms similarly moderate.

It is an extremely convenient feature of these stands that the sub-stage may be removed by a lateral slide, by which is secured a great saving of time and trouble over the ordinary arrangements. The student's binocular was the first which was introduced to meet the wants of this class of observers. An important peculiarity of the rotating stages is the newly introduced centering adjustment, by means of which rotation about the optic axis is perfectly and instantaneously secured. A centering arrangement of the diaphragm is also provided. The objectives exhibited form a series ranging from three inches to one-fourth of an inch. For sharpness of definition and freedom from distortion of image they leave nothing to be desired. They are admirably adapted to all the ordinary work of the microscope. The polariscopes exhibited deserve especial commendation for their excellent mounting and large field.

Ross & Co., London, England.

Microscopes and Photographic Lenses.

Report.—1. Microscopes.—Two forms of first-class microscope-stands are exhibited, under the names of the Ross model and the Jackson model.

The Ross model has been long known. Its merits are great stability, effective mechanical arrangements for adjustment of focus and movement of object, facility of centering the sub-stage, and convenient position of the milled heads for working. It is an advantage, also, that the arm carrying

the objectives can be turned aside, leaving the space above the stage entirely clear, and also that for convenience in packing for transportation this arm may be entirely removed.

The Jackson model differs from the Ross model in the body and bearings, but in respect to stage, sub-stage, and arrangement for illumination, is identical with it. The sliding posts and bearings are unusually broad and strong, securing great rigidity and freedom from tremor at the expense of increased weight. The perfect centering of the body and stages is secured by making a single stout bar the support of these, maintaining them therefore in an unvarying line. The distribution of weight is such as to produce a perfect balance. The positions of the milled heads are remarkably convenient, and such that the fine movement may be operated while the hand is on the coarse movement.

Microscope Objectives.—A complete series of these is exhibited from four inches to one-fifteenth inch. Those from one-half inch forward are constructed on a system introduced a few years since by Mr. Wenham, according to which a cemented triple achromatic combination is placed between two simple lenses. Certain theoretic advantages are claimed for these objectives. The low powers, especially the half-inch, perform admirably, and the high powers do well with central or slightly oblique illumination. This firm have a series in course of construction called new universal micro-objectives, of which a specimen of one-fifth inch focus is exhibited.

This objective is provided with two fronts, one of which used alone gives a low angle and long working distance, and reinforced by the other, a high angle adapted to difficult resolutions. This works dry, but by more closely approximating the two fronts is converted into an immersion objective. Another one-fifth inch is also exhibited, which acts both as a dry and immersion glass, and with an additional front is increased in power and in sharpness of definition on difficult objects in consequence of its large angle. This also works both dry and wet, with proper adjustments.

2. Photographic Lenses.—Some of these are designed for portraits, and others for landscape, architectural, and interior views. One form, called the New Universal Lens, is designed for either use.

It seems to be unnecessary to speak of these in detail, since they all possess certain excellent qualities in common, such as flatness of field, sharpness of definition, depth of focus, freedom from distortion, and large angular aperture.

By the method of construction, also, they are made very compact, and the different lenses may be interchanged upon the same flange screw. The specimens of their performance on exhibition show a remarkable uniformity of definition, both in the foreground and in the distance.

The terrestrial telescopes and field glasses of various kinds are of excellent workmanship.

R. & J. Beck, London, England.

Microscopes.

Report.—The objects exhibited are all of the highest excellence in respect to workmanship and finish. The microscope-stands exhibited are of four grades, adapted to different classes of observers. The first-class stand possesses the qualities of stability and freedom from tremor in the highest degree, the body, stage, and sub-stage being supported by a single bar of great rigidity. It is also well balanced. The arrangements for the mechanical movement of the stage, and for coarse and fine adjustments of focus, are extremely convenient. The student's microscope, or second-class stand, is simpler of construction, but possesses many of the advantages of that just described. The popular microscope is simpler still, and is furnished at a very moderate price; and, finally, the Economic microscope provides for most ordinary investigations in pathology and natural history, at a very insignificant expense. The objectives of this firm are well known for their merit. Of those exhibited, the performance of the one and a half inch and the one-tenth inch immersion is especially excellent; but all the low powers give remarkable penetration combined with sharp definition; and with the higher, difficult resolutions are

easily effected. Of apparatus accessory to microscopic observation, the exhibitors manufacture a large variety, such as the polarizing apparatus, which is so constructed that the analyzer may be placed either above or below the eye-piece. The iris diaphragm is also an admirable contrivance for conveniently varying the diameter of the illuminating pencil.

J. H. Dallmeyer, London, England.

Microscopes and Photographic Lenses.

Report.—1. Microscopes.—Two first-class microscope-stands are exhibited, a monocular and a binocular, together with apparatus for illumination, and a series of eight objectives, ranging from two inches to one-twelfth of an inch. The stands are of the pattern known as the Ross model. They are very massive, and combine strength with stability and convenience. The object-stage is mechanically moved in co-ordinate directions by rack and pinion and screw movements, and is rotated around the optic axis by means of a pinion working in toothed ring. The sub-stage has centering and focus adjustments, and is also capable of rotation. Of the workmanship and finish too much cannot be said in praise. The low-power objectives give excellent definition, superior penetration, and perfect flatness of field. The higher powers, from one-fourth inch upward to one-twelfth inch, are formed of three achromatic combinations, with angular apertures which are, theoretically, 125° for the one-fourth inch, 145° for the one-eighth inch, and 160° for the one-twelfth inch. Practically these angles are found to be sensibly less. Working dry, with central or nearly central light, excellent definition of difficult tests is obtained. The one-twelfth inch requires a cover not exceeding about one two-hundredths inch. Under oblique light, within the limit practically admissible, the resolving power and flatness of field are capable of improvement. Each of the high-power objectives is furnished with an additional front, by substituting which the glass is converted into an immersion objective, in which case the effective aperture is increased. By partially unscrewing the immersion-front, this immersion objective may be used dry with reduced angle.

2. Photographic Lenses.—Quite a variety of these lenses are exhibited, into the special merits and peculiarities of construction of each of which it seems to the reporters to be unnecessary to go. Their merits are attested by the extent to which they have been introduced into use in nearly all countries.

The large portrait lenses possess the very important property of being capable of adjustment for depth of focus, according to circumstances. This, which was first introduced in 1866, consists of a front combination formed of a double-convex crown and a concavo-convex flint cemented together, forming, unitedly, a convexo-concave system; and a back combination uncemented, consisting of a crown meniscus with a concavo-convex flint placed behind it. The mechanical approximation or separation of these last-mentioned glasses affords the means of the adjustment for depth of focus above spoken of. When the glasses are in contact, the aberrations are entirely corrected for a single plane. By their separation, *depth of focus* is secured to suit the particular occasion. This contrivance displays great ingenuity.

The lens called the *Triple Achromatic*, used for copying maps and plans of large dimensions, has been long in use. The forms called *Rectilinear*, which are of two kinds, *Rapid* and *Wide Angle Rectilinear*, are employed for groups, views, and landscapes. The first has an angle of 75°, and the second of 90°. The *Single Combination Landscape* lens is formed of two meniscus glasses of different kinds of crown glass, with an intervening flint concavo-convex, all cemented together. In use, the concave side of the system faces the landscape. It gives a picture free from flaw-spots with an angle of 70°, not entirely free from distortion on the borders, but with a brilliancy and uniformity of illumination which compensate this defect. Some very beautiful and sharply-defined pictures of the sun, with interesting groups of spots, taken at the Wilna Observatory with an instrument furnished by the exhibitor, are shown, and furnish a very satisfactory proof of the excellent performance

Great Britain and Ireland.

Group XXV.

of the photo-heliographic apparatus by means of which they were obtained. Commended for excellence of workmanship in the construction of achromatic telescopes, and for accessories and equatorial mountings for the same.

NEGRETTI & ZAMBRA, London, England.

Thermometers.

Report.—Commended for excellence of high-grade instruments. The deep-sea thermometer of this firm is worthy of especial mention.

Group XXVI.

GROUP XXVI.—ARCHITECTURE AND ENGINEERING.

WM. SMITH & SONS, Barnard Castle, Durham, England.

One-horse Machine for cleaning Streets and Roads of Dust and Mud.

Report.—They are simple, strong, and well constructed, and seem well adapted for their purpose.

DIRECTOR-GENERAL OF THE ORDNANCE SURVEY, Southampton, Great Britain.

Maps of Ordnance Survey.

Report.—Commended for extreme accuracy of work and beauty of execution, and excellent manner in which the large maps are reduced by photography.

JOHN BARTHOLOMEW, Edinburgh, Scotland.

Maps and Plans of Towns.

Report.—Commended for the apparent accuracy and the neatness of execution.

EDGE & SONS, Coalport Works, Shifnal, Shropshire, England.

Wire Ropes and Chains for Mining and Engineering Purposes.

Report.—Commended for an exhibit of the above-named articles in many sizes, from quite small to very large, and all of superior excellence.

Group XXVII.

GROUP XXVII.—PLASTIC AND GRAPHIC ART.

MAW & Co., London, England.

Mosaics in Tiles.

Report.—Commended for the admirable adaptation of the groupings of tile exhibited to purposes of interior decoration, in shape of wainscot, panelling, chimney ornamentations, and for hearths and flooring.

MINTON, HOLLINS, & Co., London, England.

Mosaic Work in Tiles.

Report.—Commended for artistic management of colours, effective grouping in decorative panels, more especially of those which are designed and arranged for chimney and hearth ornamentation.

ROYAL SCHOOL OF ART NEEDLEWORK, London, England.

Decorative Needle-work.

Report.—Commended for artistic designs and excellent execution of various styles of needle-work adapted for hangings of furniture, the introduction of which into more general use would give employment to a better class of workers and vary the decoration of interiors.

E. J. Poynter, R.A., London, England.

Cartoons from Mosaics.

Report.—Very fine cartoons; good style and very decorative.

G. A. Audsley & J. L. Bowes, London, England.

Illustrations of Ceramic Art in Japan.

Report.—Commended for excellent and artistic specimens of illustrations of the ceramic art of Japan.

Elkington & Co., Birmingham and London, England.

Inlaid Work in Metal.

Report.—Commended for great beauty of design and perfect execution.

Cox & Sons, London, England.

Forged Metal Work; Stained Glass and Decorative Panels.

Report.—The judges have grouped the above products together as showing great artistic excellence and for their happy adaptation to purposes of interior decoration.

Ortner & Houle, London, England.

Seals and Dies.

Report.—Commended as finely cut and artistic in design.

Elkington & Co., Birmingham and London, England.

Bas-reliefs in Metal, Electrotype and Repoussé Work.

Report.—Commended for their remarkable exhibit of bas-reliefs, electrotype copies, and original specimens; also for superior excellence of repoussé work in silver and iron, showing a very high standard of artistic merit.

M. Feetham & Co., London, England.

Artistic Castings and Forged Metal for Chimney Decoration.

Report.—Commended for excellence and variety of designs for chimney appurtenances, being artistic in character and contributing largely by their use to effective decoration of interiors.

Jeffrey & Co. (Mr. Crane, Designer), London, England.

Design for Wall Paper.

Report.—Commended for great excellence and chastity of design, connected with exceedingly harmonious colouring. Altogether, a most artistic exhibit of the large decorative effect which is possible with this material in the hands of a clever designer.

Hart, Son, Peard, & Co., London, England.

Forged Metal Work.

Report.—Commended for artistic design and admirable execution characterising the varied objects submitted by the exhibitor. If we were to particularise, it would be by naming the great forged candelabra in the centre of main aisle, and various gates within the immediate compartment of the exhibitors.

Barnard, Bishop, & Barnards, London, England.

Artistic Castings and Forged Work in Iron.

Report.—Commended for remarkably sharp and clean castings, showing well-defined, delicate lines, and great variety of artistic designs; also well-executed forgings in various forms.

Great Britain and Ireland.

Group XXVII.

T. H. Wyatt, London, England.

Designs for Country and Town Houses.

Report.—Commended for excellent classic treatment of the large designs exhibited, and very pleasing composition as regards form and colour, for the country house of Mr. Morant.

William Burgess, F.R.S.B.A., London, England.

Design for New Tower at Cardiff, New Law Courts.

Report.—Commended for their careful study and artistic treatment of exteriors.

F. C. Penrose, M.A., F.R.A.S., London, England.

Design for Decoration of St. Paul's Cupola.

Report.—Commended for general excellence of treatment, the designs being in harmony with the style of the cathedral.

Henry Cooper, London, England.

Interior Decoration of St. George's House.

Report.—Attention is called to the very effective and highly artistic decoration of the interior of St. George's House, built by the British Commissioners.

Wright & Mansfield, London, England.

Decoration of Interior.

Report.—Commended for the artistic execution of the decoration of the side of a drawing-room in the style of the latter part of the eighteenth century.

Geo. Aitchison, F.R.I.B.A., Tower Hill, London, England.

Industrial Design (Furniture).

Report.—Commended for good taste in design and faithful elaboration of details. We particularly designate the "sewing table" and the studies for ceilings and walls of "drawing-room."

John Hardman & Co., Birmingham, England.

Stained Glass Window.

Report.—Commended for good drawing; harmonious colour; great clearness of tint. Great awkwardness in results, from introducing a lighted ceiling in perspective, but the general work excellent in manner, and according with the best traditions of the art of glass staining.

William Ramsey, London, England.

Window Screens of Stained Glass.

Report.—The screens are excellent in designs, and treated with such monochromatic and translucent tints as greatly favour their adoption for domestic uses. Thus, without undue sacrifice of light, this art may be made to minister very happily to household decoration.

Heaton, Butler, & Bayne, London, England.

Stained Glass.

Report.—Commended for the admirable drawing and generally effective treatment, and more especially for the artist's bold seizure upon homely subjects, thus opening the way for a happy adaptation of this art to purposes of domestic decoration.

J. Saddler, England.

Wood Engraving.

Report.—Commended for firm, vigorous, and finely-executed wood engravings.

T. Oldham Barlow, A.R.A., England.

Engravings.

Report.—Commended for excellence in execution and firmness in tone.

C. G. Lewis, England.

Engravings.

Report.—Commended for excellence in reproducing the characteristic merits of paintings.

Joseph Swain, England.

Wood Engraving.

Report.—Commended for excellence in wood engraving; firm, vigorous, and delicate expression.

John Leighton, F.S.A., London, England.

Etchings printed from Relief.

Report.—Commended for excellence in workmanship.

Edwin Edwards, England.

Etchings.

Report.—Commended for excellent specimens of etchings.

Arthur Evershed, England.

Dry-point Etchings.

Report.—Commended for excellent specimens of etchings.

Francis Seymour Haden, England.

Etchings on Copper.

Report.—Commended for excellent specimens of etchings; boldly etched; great spirit shown.

J. P. Heseltine, England.

Etchings.

Report.—Commended for excellence in etching.

Cassell, Petter, & Galpin, London, England.

Lithographs and Chromo-Lithographs.

Report.—Commended for artistic excellence in lithography and chromo-lithography, works on ornament.

Marcus Ward & Co., London, England.

Chromo-Lithographic Illustrations.

Report.—Commended for excellent and artistic specimens of book illustrations.

DU MAURIER, London, England.

Drawings with Pen.

Report.—Commended for excellence in design, firmness in execution, and high character in style.

LONDON GRAPHIC CO., London, England.

Drawings and Wood Engravings.

Report.—Commended for the promotion of excellence in design and engravings, and for their superior collection of original designs.

A. HENDERSON, London, England.

Photographs.

Report.—Commended for photo-enamels.

WILLIAM BEDFORD, London, England.

Photographs.

Report.—Commended for artistic landscape photographs.

VERNON HEATH, London, England.

Photographs.

Report.—Commended for artistic and technical excellence of large landscape photographs by the carbon process.

COLONEL STUART WORTLEY, London, England.

Photographs.

Report.—Commended for artistic landscape studies and technical excellence of uranium dry plates.

JULIA MARGARET CAMERON, Isle of Wight, England.

Photographs.

Report.—Commended for good taste and artistic composition of photographs.

H. P. ROBINSON, Leamington, England.

Photographs.

Report.—Commended for artistic excellence of landscape studies.

FREDERICK YORK, London, England.

Photographs.

Report.—Commended for stereoscopic photographs of animals.

CARL NORMAN, Tunbridge Wells, England.

Photographs.

Report.—Commended for good landscape photographs.

THE LONDON STEREOSCOPIC AND PHOTOGRAPHIC CO., London, England.

Photographs.

Report.—Commended for imperial-size photographs.

FREDERICK HUDSON, Ventnor, Isle of Wight, England.

Photographs.

Report.—Commended for artistic landscape photographs.

PAYNE JENNINGS, Dublin, Ireland.

Photographs.

Report.—Commended for the highest artistic excellence in landscape photography.

H. S. MARKS, London, England.

Painting in Water-Colour.

Report.—Commended for artistic excellence.

L. ALMA TADEMA, London, England.

Painting in Water-Colour.

Report.—Commended for artistic excellence and great beauty in design, colour, and tone, and refinement of execution.

J. D. LINTON, London, England.

Painting in Water-Colour.

Report.—Commended for artistic excellence and rich, full colour, excellent design and execution.

J. M. JOPLING, London, England.

Painting in Water-Colour.

Report.—Commended for artistic excellence.

A. P. NEWTON, London, England.

Painting in Water-Colour.

Report.—Commended for artistic excellence.

W. CALLOW, London, England.

Painting in Water-Colour.

Report.—Commended for artistic excellence.

L. G. POTT, London, England.

Oil Painting.

Report.—Commended for great merit in genre painting, historical class, "Charles the First leaving Westminster Hall after his Trial."

P. F. POOLE, London, England.

Oil Painting.

Report.—Commended for excellence in genre painting, "The Lion in the Path."

MISS M. D. MUTRIE, London, England.

Oil Painting.

Report.—Commended for great merit in genre painting.

MISS A. F. MUTRIE, London, England.

Oil Painting.

Report.—Commended for great merit in genre painting.

GEORGE D. LESLIE, London, England.

Oil Painting.

Report.—Commended for excellence in genre painting, "The Arbor."

ALFRED ELMORE, London, England.

Oil Painting.

Report.—Commended for excellence in genre painting.

L. ALMA TADEMA, London, England.

Oil Painting.

Report.—Commended for artistic excellence in historical painting: "The Vintage Festival;" "The Mummy."

FRANK HOLL, London, England.

Oil Paintings.

Report.—Commended for artistic excellence—genre: "The Lord gave, the Lord hath taken away; blessed be the name of the Lord;" "I am the resurrection and the life."

MARCUS STONE, London, England.

Oil Painting.

Report.—Commended for artistic excellence—genre, "My Lady is a Widow and Childless."

CHAS. EDW. PERUGINI, London, England.

Oil Painting.

Report.—Commended for artistic excellence in portrait, "Portrait of Mrs. C. E. Perugini."

J. CLARK, London, England.

Oil Painting.

Report.—Commended for artistic excellence—genre, "The Sick Child."

HEYWOOD HARDY, London, England.

Oil Painting.

Report.—Commended for artistic excellence—animals, "The Disputed Toll."

S. LUKE FILDES, London, England.

Oil Painting.

Report.—Commended for artistic excellence—genre, "Betty."

PETER GRAHAM, London, England.

Oil Painting.

Report.—Commended for artistic excellence in landscape, "Wind."

COLIN HUNTER, London, England.

Oil Painting.

Report.—Commended for artistic excellence in landscape, "Trawlers Waiting for the Darkness."

VICAT COLE, London, England.

Oil Painting.

Report.—Commended for artistic excellence in landscape, "Noon."

THOMAS FAED, Essex, England.

Oil Painting.

Report.—Commended for artistic excellence—genre, "Baith Faither and Mither."

SIR FRANCIS GRANT, London, England.

Oil Painting.

Report.—Commended for artistic excellence in portrait, "The Late Viscount Hardinge, Governor-General of India, Returning from the Battle of Ferozeshah."

FREDERICK LEIGHTON, London, England.

Oil Painting.

Report.—Commended for artistic excellence in historical and poetical painting: "Summer Moon;" "Interior of a Jew's House, Damascus."

GEORGE H. BOUGHTON, London, England.

Oil Painting.

Report.—Commended for artistic excellence—genre, "God Speed."

WM. POWELL FRITH, London, England.

Oil Painting.

Report.—Commended for excellence in genre painting and portraiture: "The Marriage of H.R.H. the Prince of Wales in St. George's Chapel, Windsor, March 10, 1863,"—lent by Her Majesty the Queen; "The Railway Station;" "Pamela."

B. RIVIERE, London, England.

Oil Painting.

Report.—Commended for excellence in genre painting, as shown in his pictures "Circe and the Companions of Ulysses," and "War Time."

W. Q. ORCHARDSON, London, England.

Oil Painting.

Report.—Commended for great excellence in landscape painting, "Moonlight on the Lagoons, Venice," and picture entitled "Prince Henry, Poins, and Falstaff."

FRANK M. GOOD, London, England.

Views of Palestine.

Report.—Good in every technical quality, and very artistic in selection of view and in lighting.

THE TYPOGRAPHIC ETCHING CO., London, England.

Engravings by the Typographic Process.

Report.—Their reproductions of existing originals shown in prints from relief plates, remarkably clear and perfect in detail.

J. S. & A. B. WYON, London, England.

Medals and Seals.

Report.—Commended for superiority of design and execution.

Great Britain and Ireland.

Group XXVII.

ERSKINE NICOL, London, England.

Oil Painting.

Report.—Commended as meritorious in genre painting, as shown in his "Paying the Rent."

CHRISTIAN WILLIAM DASHWOOD, London, England.

Original Designs for Oil Cloth.

Report.—His three designs, one Egyptian, one Arabian, and the other representing inlaid stones, well drawn, effectively coloured, and well adapted for reproduction by block printing.

GEORGE TINWORTH, London, England.

Terra-cotta Panels of Scriptural Subjects.

Report.—Commended for very artistic productions in terra-cotta of Scriptural subjects, showing artistic merit of high order.

Group XXVIII.

GROUP XXVIII.—EDUCATION AND [SCIENCE.

ORDNANCE SURVEY OFFICE, Southampton, England.

Collection of Maps for Exhibition.

Report.—Commended for the superiority of the work.

ILLUSTRATED LONDON NEWS, London, England.

Specimens illustrating the Art Department of the Illustrated News.

Report.—Commended for excellence of illustration.

J. M. JOHNSON & SONS, London, England.

Printing in Colour, Show Tablets.

Report.—Commended for excellence in typography.

THE BRITISH AND FOREIGN BLIND ASSOCIATION, London, England.

Writing Frames and Books for the Blind.

Report.—Valuable appliances for the instruction of the blind.

ANDREW MURRAY, F.L.S., London, England.

Illustrations and Specimens of Galls produced from Mites.

Report.—A very attractive and useful collection.

BRITISH AND FOREIGN BIBLE SOCIETY, London, England.

Bibles.

Report.—An extensive, interesting, and valuable exhibit of translations of the Bible, made under the auspices of the society.

LOCKWOOD CROSBY & Co., London, England.

Books, Rudimentary, Scientific—Weale's Series.

Report.—Commended for general excellence, especially for popular use.

CASSELL, PETTER, & GALPIN, London, England.

Illustrated Books, Publications, and Serials.

Report.—Commended for excellence of illustrated works for popular circulation; works well chosen and well produced.

ROBERT POTTS, Trinity College, Cambridge, England.

Educational Books.

Report.—Valuable publications, handsomely brought out.

ROBERT WARNER, London, England.

Books (Two Vols.) "Select Orchidaceous Plants."

Report.—Commended as an important contribution to science.

AUDSLEY & BOWES, Liverpool, England.

Works in Folio on the "Keramic Art in Japan."

Report.—A valuable and beautiful publication illustrating Oriental art.

SUNDAY-SCHOOL UNION, London, England.

Works for Sunday-Schools.

Report.—Commended for the extent and value of its publications for the people.

THE "GRAPHIC" NEWSPAPER, London, England.

Illustrated Newspaper.

Report.—Excellence in designs and engravings.

GEO. AUGENER & Co., London, England.

Pauer's Complete Editions of the Musical Classics.

Report.—Commended for excellence in choice and production of musical works.

NOVELLO, EWER, & Co., London, England.

Musical Works.

Report.—Commended for excellence in selection and production of musical works.

BRADBURY, AGNEW, & Co., London, England.

Books and Specimens of Engravings and Processes.

Report.—Commended for excellence in typography and illustration.

SAMUEL PALMER, London, England.

Index to the Times Newspaper.

Report.—Commended for great practical value in studies of contemporary history.

W. & A. K. JOHNSTON, Edinburgh, Scotland.

Maps and Illustrations of Human Anatomy.

Report.—Good and important means of instruction.

JOHN BARTHOLOMEW, Edinburgh, Scotland.

Maps.

Report.—Commended for excellence in lithographic printing applied to maps.

GEOLOGICAL SURVEY OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

Geological Maps.

Report.—Commended for the great superiority and excellence of the work.

Great Britain and Ireland.

Group XXIX.

Group XXIX.—Horticulture.

James Veitch & Sons, Chelsea, London, England.

Ornamental Trees and Shrubs.

Report.—A very rare collection of rhododendrons, hollies, new and rare conifers, broad-leaved evergreens, and flowering shrubs. A collection of new evergreens, of the best kinds, for lawn decorations.

Anthony Waterer, Woking, Surrey, England.

Ornamental Trees and Shrubs.

Report.—A most extensive collection and magnificent floral display of hardy and greenhouse rhododendrons and azaleas.

B. S. Williams, London, England.

Ferns.

Report.—A small collection of filmy and other ferns.

B. S. Williams, London, England,

Hothouse and Greenhouse Plants.

Report.—A very choice collection of new and rare plants, well grown, and in excellent condition after trans-shipment of such delicate articles; an exceedingly creditable display.

James Veitch & Sons, Chelsea, London, England.

Plants.

Report.—An exhibit of evergreen plants, consisting of the best varieties of rhododendrons, hollies, aucubas, etc. Commended for fine growth and careful training, and as unique in new kinds.

H. Doulton & Co., Lambeth, London, England.

Terra-Cotta Ware.

Report.—Terra-cotta reproduction of Diana, colossal size, carefully executed in regard to details, suited to public parks and grounds. Also elaborately ornamented vases of the same material.

Wm. Bull, Chelsea, London, England.

Coloured Plates of Flowers.

Report.—Drawings, coloured from nature, of ornamental flowering plants.

Group XXXI.

Group XXXI.—Cattle.

Benjamin St. John Ackers, Gloucestershire, England.

Short-horn Cattle.

Report.—Heifer "Baroness Pawlett," heifer "Cassandra," bull "Clovis." In form, quality, and useful characteristics they are entitled to rank as superior specimens of the short-horn breed.

Bull "Cymbeline." For excellence in form, quality, and useful characteristics he is entitled to rank as a superior specimen of the short-horn breed. Especially excellent in hair, and in depth and quality of flesh.

Heifer "Wedding Day." For high excellence in form and quality, and useful characteristics, she is entitled in all respects to rank as a first-class specimen of the short-horn breed. A remarkable heifer, fine hair, substance and quality.

Group XXXII.—Sheep.

Hugh Aylmer, West Dereham Abbey, Norfolk, England.

Cotswold Sheep.

Report.—One ram, one year old. Commended as a first-class specimen of the breed.

Three rams, each one year old. Commended as excellent specimens of their breed.

A. J. Milton Druce, Eynsham, England.

Oxford-Down Ram.

Report.—"Freeland," two years old. Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as a very superior specimen of the breed to which it belongs.

Henry Overman, Weasenham, Brandon, Norfolk, England.

Oxford-Down Rams.

Report.—One ram, three years old; one ram, one year old; shearling ram. Commended as first-class specimens of the breed to which they belong.

One ram, two years old. Commended for excellence in quality, uniformity, symmetry, great constitutional development, and as a very superior specimen of the breed to which it belongs.

Russell Swanwick, Gloucestershire, England.

Cotswold Sheep.

Report.—One ram, four ewes, three breeding ewes, three shearling ewes; one ram, two years old; flock, one ram, four breeding ewes; two rams, each one year old; one ram. Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as very superior specimens of the breed to which they belong.

One ram, three years old; three breeding ewes; one ram; three shearling ewes. Commended as first-class specimens of the breed.

Lord Walsingham, Merton Hall, Thetford, England.

Southdown Sheep.

Report.—Four shearling rams and and two two-year-old rams. Commended as excellent specimens of their breed.

Three shearling rams, and two two-year-old rams. Commended as first-class specimens of the breed to which they belong.

Six shearling ewes, one shearling ram, and one two-year-old ram. Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as very superior specimens of the breed to which they belong.

Group XXXIII.—Swine.

Benjamin St. John Akers, Gloucestershire, England.

Berkshire Swine.

Report.—Boar "Collier," sow "Snow-flake," and sow with five pigs. Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as very superior specimens of the breed to which they belong.

Great Britain and Ireland.

Group XXXIV.

Group XXXIV.—Dogs.

Major Arthur Leech (Irish Rifle Team), Dublin, Ireland.

Irish Terrier Paddy.

Report.—Is purely bred, excellent quality, and looks like a thorough workman.

J. C. Cooper, Cooperhill, Limerick, Ireland.

Imported Irish Setter Dog; Imported Irish Setter Dog; Imported Irish Setter Bitch.

Robert S. Greenhill, Dublin, Ireland.

Imported Irish Setter Dog.

J. K. Millner, Blackrock, Dublin, Ireland.

Imported Irish Setter Bitch.

Group XXXV.

Group XXXV.—Poultry.

John H. Cryer, Southport, England.

Pigeons.

Report.—One pair of black barbs. Commended as superior specimens of their breed.

One pair of blue English carriers. Commended as excellent specimens of their breed.

One pair of silver owls. Commended as meritorious specimens of their breed.

James C. Cooper, Limerick, Ireland.

Game Fowls.

Report.—Three pairs of game fowls. Commended as excellent specimens of their breed.

Collective Exhibits.

Collective Exhibits.

British Government.

Collective Exhibit.

Report.—Three buildings, erected on the Centennial grounds, in the style of the Elizabethan age; also interesting collections and contributions from the South Kensington Museum.

Lords of Committee of Council on Education, England.

Contributions from South Kensington Museum.

Report.—A very interesting collection of contributions from the South Kensington Museum, arranged by its able director, Mr. P. Cunliffe Owen.

BAHAMAS.

Group IV.—Animal and Vegetable Products, and the Machinery for their Preparation.

R. H. Sawyer & Co., Bahama Islands.

A Collection of Sponges.

Report.—Commended for the good quality of the sponges, and the extent of the collection; to wit, sheep's-wool sponges, yellow sponges, velvet sponges, grass sponges, and reef sponges.

C. H. Robinson, Nassau, Bahama Islands.

Honey.

Report.—Commended for fine flavour and well-preserved quality of wild honey.

John S. George, Nassau, Bahama Islands.

Vegetable Wax.

Report.—A sample of myrtle wax; novel and useful in producing artificial light.

Group V.—Fish and Fish Products, Apparatus of Fishing.

Mrs. M. E. Gardner, Nassau, Bahamas.

Shell work.

Report.—Commended for excellence of design.

Mrs. S. E. Robertson, Nassau, Bahamas.

Shell work.

Report.—Commended for good design and excellence of work.

Group VI.—Timber, Worked Timber, Parts of Buildings, Forestry.

R. H. Sawyer & Co., Bahama Islands.

Woods and Timbers, Dye Woods, Vegetable Wax, and Barks.

Report.—Commended for the variety and excellence of the articles.

Collective Exhibit.

Government of Bahama Islands.

Collective Exhibit.

Report.—A large display of the natural products of these islands.

Bermuda.

BERMUDA.

Group I.

Group I.—Minerals, Mining and Metallurgy, including the Machinery.

P. Ness, Island of Bermuda, West Indies.

Building Stones of Bermuda.

Report.—Commended for the representative character of the collection, and the adaptation of the stones for the purposes they serve.

Group IV.

Group IV.—Animal and Vegetable Products, and the Machinery for their Preparation.

T. F. Tucker, Hamilton, Bermuda.

Arrowroot.

Report.—A product of snowy whiteness, and every way excellent.

Group V.

Group V.—Fish and Fish Products, Apparatus of Fishing.

Government of Bermuda.

Collection of Bermuda fish alive, including Parrot-fish, Grunts, Squirrel-fish, and Groopers.

Report.—Commended for general character of exhibit, as illustrating the fish of Bermuda in their live state.

Government of Bermudas.

Shells, Corals, Sponges, Sea-fans, and Echinoderms.

Report.—Commended for variety and excellence of specimens exhibited.

Group VI.

Group VI.—Timber, Worked Lumber, Parts of Buildings, Forestry.

J. Ming Hayward, Bermuda Islands.

Arrowroot.

Report.—An interesting and complete collection of arrowroot, both raw and manufactured.

Group XIX.

Group XIX.—Vessels and Apparatus of Transportation not included in other Groups.

The Government of Bermuda.

Floating Dock.

Report.—Commended for design, workmanship, and success in accomplishing the purpose for which it was intended.

Collective Exhibit.

Collective Exhibit.

Government of Bermuda.

Collective Exhibit.

Report.—A large display of natural products of the islands.

BRITISH GUIANA.

British Guiana.

Group III.—Chemistry and Pharmacy, including the Apparatus.

Group III.

Plantation "Ogle," British Guiana.

Sugar.

Report.—Commended for the excellent quality and condition of samples of vacuum-pan sugar.

Plantation "La Bonne Intention," British Guiana.

Sugar.

Report.—Commended for the fine quality and condition of crystallized sugar made in the vacuum-pan, and also more especially that produced by the maceration process.

Plantation "Leonora," British Guiana.

Sugar.

Report.—Commended for excellence of results obtained by the maceration process.

Plantation "Great Diamond," British Guiana.

Sugar.

Report.—Commended for the excellent character of crystallized sugar made by vacuum-pan boiling.

Collective Exhibit.

Collective Exhibit.

Government of British Guiana.

Collective Exhibit.

Report.—A very large display of its natural products.

CANADA.

Canada.

Group I.—Minerals, Mining and Metallurgy, including the Machinery.

Group I.

Geological Survey of Canada.

Geological Collection.

Report.—A large collection of economic minerals of the Dominion of Canada, including the ores of iron, lead, antimony, copper, silver, gold, and platinum, together with marbles, slates, and building stones; a collection showing the various rock formations; a very fine and complete series of specimens illustrating the history of *Eozoon Canadense*, and the geological maps hitherto published by the geological survey.

Dr. Honeyman, Halifax, Nova Scotia.

Geological Collection.

Report.—A geological collection showing the distribution of erratic rocks in Nova Scotia.

Canada. Group I.

WATERMAN BROS., London, Ontario, Canada.

Petroleum.

Report.—A fine display of petroleum, crude and manufactured paraffine, &c.

NOVA SCOTIA SECTION OF CANADIAN COMMISSION.

Collection of Building Stones.

Report.—Commended for the representative character of the collection and general good quality of materials exhibited.

JOHN RANKIN, Actonvale, Canada.

Collection of coloured Slates.

Report.—Commended for the good quality of the slates, and the variety of colours, red, green, and black, which they exhibit.

HOPEWELL QUARRY CO., Hopewell, New Brunswick.

Sandstone.

Report.—Commended for the good colour and uniform texture of the stone.

GEO. J. MCDONALD & CO., Cornwallis, Nova Scotia.

Building Stone.

Report.—Commended for the good quality of the material.

BAY OF FUNDY RED GRANITE CO., St. George, New Brunswick.

Wrought Red Granite.

Report.—Commended for the beauty, homogeneity, and strength of the material, and for the high polish given it.

DANVILLE SLATE CO., Danville, Quebec, Canada.

Slate.

Report.—Commended for the variety of the exhibit and the good quality of the material.

P. T. SOMERVILLE, Arnprior, Canada.

Monuments of dark clouded Marble of Arnprior.

Report.—Commended for good quality of material and workmanship of articles exhibited.

NEW ROCKLAND SLATE CO., Montreal, Canada.

Roofing Slate and Slate Slabs from Melbourne, Canada.

Report.—Commended for the variety and extent of the exhibit, the strength, uniformity of texture and surface, and purity of colour of the slate.

ROBERT FORSYTH, Montreal, Canada.

Red Granite Monuments, &c., from Gananoque.

Report.—Commended for the variety and workmanship of the objects exhibited, and for the good colour, homogeneity, and strength of the material.

DANIEL & BOYD, St. John, New Brunswick.

Block of Freestone.

Report.—Commended for the uniform colour and texture of the stone.

DORCHESTER UNION FREESTONE Co., Budreau, New Brunswick.

Building Stone.

Report.—Commended for the uniform texture, good colour, and strength of the stone exhibited.

ONTARIO LITHOGRAPHIC STONE Co., Marmora, Ontario, Canada.

Lithographic Stones.

Report.—Commended for the quality of the material.

JOHN KELLEY, Belleville, Ontario, Canada.

Lithographic Stones.

Report.—An exhibit of stones of good texture for the purposes intended.

JOSEPH GOODFELLOW, North Elk, New Brunswick.

One large Grindstone.

Report.—Commended for the size and good quality of the grindstone exhibited.

DOMINION OF CANADA PLUMBAGO Co., Ottawa, Ontario, Canada.

Graphite, and Products manufactured therefrom.

Report.—Commended for an exhibit of much scientific interest, and for the superior quality of crude and manufactured graphite.

A. SEAMEN & Co., Lower Cove, Nova Scotia.

Grindstones.

Report.—An exhibit of stones, mounted and unmounted, of good quality.

GRAY, YOUNG, & SPARLING, Eclipse Well, Seaforth, Ontario, Canada.

Refined Salt.

Report.—Commended for the good quality of the various grades of salt.

ALEXANDER COWAN, Brockville, Canada.

Phosphate of Lime, Pyrites, &c.

Report.—A collection of pyrites, apatite, &c., illustrating the treatment of mineral phosphates.

GATLING GOLD MINING Co., Marmora, Canada.

Gold Ores.

Report.—An interesting exhibit of gold and silver bearing arsenical pyrites; with the metals extracted therefrom.

SILVER MINING Co. OF SILVER ISLET, Ontario, Canada.

Silver and Silver Glance.

Report.—A curious and valuable exhibit of native silver and silver glance (sulphuret of silver).

R. ROBERTSON, Halifax, Nova Scotia.

Gold Specimens.

Report.—A collection illustrative of the gold fields.

Canada.

Group I.

STEEL CO. OF CANADA, Londonderry, Canada.

Ores, Iron, and Steel.

Report.—Commended for good quality of pig iron.

W. W. STUART, Montreal, Canada.

Native Copper.

Report.—An interesting exhibit of native copper in sandstone, from Michipicoten Lake.

NOVA SCOTIA.

Coals.

Report.—Commended for the fine and beautiful exhibit made. The coals are adapted for domestic, steam, and gas purposes, and of superior quality.

LAKE GEORGE ANTIMONY CO., Prince Williams, New Brunswick.

Regulus of Antimony.

Report.—For the good quality of the ores, and of the samples of antimony regulus.

Group II.

GROUP II.—POTTERY, GLASS, ARTIFICIAL STONE, &C.

GEORGE SYLVESTER TIFFANY, London, Ontario, Canada.

Brick and Tile-making Machine,—an Expressing Machine.

Report.—The machine is simple and strong in the arrangement of its component parts, and its price is low. It also embodies the novel and valuable device of a propeller for forcing the clay through the die, which revolves in a direction opposite to the motion of the pug-mill, and much more rapidly.

BULMER & SHEPPARD, Montreal, Canada.

Four Common Bricks.

Report.—The bricks are of good quality and colour, and are well fired.

LEE BROS., St. John, New Brunswick, Canada.

Common Hard Bricks.

Report.—The bricks are of good quality, being very hard and strong, well moulded and fired, and of an agreeable dark red colour.

THE DOMINION OF CANADA PLUMBAGO CO., Buckingham, Canada.

Plumbago Crucibles.

Report.—Commended as well made and durable.

WM. MCKAY, Ottawa, Ontario, Canada.

Hydraulic Cement (a patented Article).

Report.—McKay's patent cement is of fair average quality as compared with the good grades of Portland cement, but possesses three times the strength and hardness of ordinary quick-setting natural hydraulic cements.

P. GAUVREAU & Co., Quebec, Canada.

Hydraulic Cement and Artificial Stone.

Report.—The cement is quick-setting and excellent of its kind, and the specimens of artificial stone are fairly moulded, and of sufficient strength and hardness for the purposes for which they are severally intended.

ALBERT MANUFACTURING CO., Hillsborough, New Brunswick, Canada.

Raw and Calcined Gypsum.

Report.—The plaster is of excellent quality, is pure white, and is very valuable for decorative purposes, especially when artistic finish is desired.

ST. JOHN'S STONE CHINAWARE CO., Quebec, Canada.

White Granite Wares.

Report.—Commended for fair quality of body and glaze, good quality of colour in blue decoration.

GROUP III.—CHEMISTRY AND PHARMACY, INCLUDING THE APPARATUS.

LYMAN BROTHERS & CO., Toronto, Ontario, Canada.

Chemicals.

Report.—Commended for excellence of quality of various chemicals used in pharmacy.

INTERNATIONAL SALT CO., Goderich, Ontario, Canada.

Salt.

Report.—The fishery and fine salt shown are both very clean, white, and dry, the product of Canadian salt wells.

HARRISON & EVANS, Goderich, Ontario, Canada.

Salt.

Report.—Commended for the excellent exhibit of fishery salt, of very large grain, dry and well drained.

GRAY, YOUNG, & SPARLING, Seaforth, Ontario, Canada.

Salt.

Report.—Commended for the exhibition of dairy and table salt of excellent quality, with the natural brine from which these are made.

ALEX. COWAN, Brockville, Ontario, Canada.

Superphosphates and material for Superphosphates.

Report.—Commended for the excellent quality of the apatite, intended for the manufacture of superphosphate, and for the good manufacture of the latter.

GEORGE W. MORSE & CO., Toronto, Ontario, Canada.

Soaps and Candles.

Report.—Commended for the quality of the soaps, for the excellent manufacture of tallow candles in imitation of stearine candles.

ALBERT TOILET SOAP CO., Montreal, Canada.

Toilet Soaps, Oils, and common Soaps.

Report.—Commended for the quality of their soaps and of the oil used in their manufacture; for the importance given their manufacture.

A. W. HOOD & SON, Montreal, Canada.

Soaps.

Report.—Commended for the quality of their toilet and common soaps.

Canada.

Group III.

WATERMAN BROTHERS, London, Ontario, Canada.

Paraffine.

Report.—Commended for the general excellence and scale of manufacture from Canadian raw petroleum of a series of petroleum products, including so-called benzine, head-light, and other burning oils, lubricating oils of different kinds, paraffine and paraffine candles,—all of superior quality.

ROBERT FREELAND, Toronto, Ontario, Canada.

Machine for Boiling Soap under Pressure.

Report.—Commended for the convenient arrangement and adaptation to intended use of small machine (working model) shown. The features most worthy of notice are the division of the vertical cylinder, to contain the grease and alkaline lye, into two portions by a loose internal (vertical) cylinder, in the centre of which is the coil of steam-pipe for heating, ascending and descending currents being thus produced, which dispense with mechanical arrangements for stirring, and the arrangement of cocks for filling and emptying under pressure. The machine may also be used in the preparation of pharmaceutical extracts.

BUCHANAN MINERAL CO., Walsingham, Ontario, Canada.

Mineral Paint.

Report.—Commended for the superior quality and variety of shades of mineral paint.

LYMANS, CLARE, & CO., Montreal, Canada.

Pigments and Oils.

Report.—Commended for excellence of quality of Canada balsam, linseed oil, and ground colours, as used by painters.

T. RAMSAY, Montreal, Canada.

Pigment.

Report.—Commended for the production of a new white pigment of great body and not liable to blacken.

A. RAMSEY & SON, Montreal, Canada.

Paints.

Report.—Commended for the good quality of ground paints exhibited.

WM. HESSIN, Toronto, Ontario, Canada.

Bonbons of Sugar.

Report.—The exhibitor presents a good general assortment of well-made bonbons, comfits, and lozenges, displaying both taste and skill.

O. V. TROOP & Co., St. John, New Brunswick.

Vinegar.

Report.—Commended for the good quality and cheapness of vinegar exhibited.

MICHAEL LE FEVRE, Montreal, Canada.

Vinegar.

Report.—Commended for the good quality of vinegar exhibited, produced in quantity at moderate price.

Group IV.—Animal and Vegetable Products, and the Machinery for their Preparation.

Edwardsburg Starch Co., Edwardsburg, Quebec, Canada.

Starch.

Report.—A product very white, sweet, pure, and strong.

Catelli Brothers, Montreal, Canada.

Farina and Potato Starch.

Report.—1. A very good quality of farina, made with the hardest wheat grown in Canada.

2. A very good quality of potato starch.

Catelli Brothers, Montreal, Canada.

Maccaronis, Soup Pastes, &c.

Report.—Commended for fine appearance, firmness of paste, good material and colour.

M. B. Spinelli, Montreal, Canada.

Fancy Soup Pastes, White and Yellow.

Report.—Commended for the following reasons:

1. Fine appearance and colour.
2. Firmness.
3. Made with good farina.
4. Great variety.

W. Weatherstone & Co., Toronto, Ontario, Canada.

Flour.

Report.—Colour good, strength fair; a family flour, but not of the highest grade. Quality of wheat uncertain; method of grinding unknown.

J. G. King, Port Hope, Toronto, Canada.

Flour.

Report.—Flour from winter wheat, of good colour, great strength, and adapted for general consumption, without any special qualities.

Flour from winter wheat, of very fine colour, fair strength, makes good bread, but especially adapted for biscuit and pastry; also a family flour of very fine colour, fair strength; a family flour of fine colour and fair strength; a family flour of good colour and fair strength; all three from wheat the quality of which is uncertain and the method of grinding unknown.

Shirk & Snider, Bridgeport, Ontario, Canada.

Flour from Winter Wheat.

Report.—Colour fine, strength fair; adapted for general consumption, without any special qualities.

Brodie & Harvey, Montreal, Canada.

Graham Flour.

Report.—Colour fine; well milled.

BRODIE & HARVEY, Montreal, Canada.

Self-raising Flour.

Report.—Commended for the following reasons:

1. It produces a light, porous, and very digestible bread, without the loss attendant on fermentation, which is greater than the additional cost of the self-raising flour.
2. Should there be a deficiency of phosphates in the diet, the material used in this bread will supply that defect.

STARR MILLS, Bridgetown, Canada.

Buckwheat Flour.

Report.—Commended for fair colour and good quality.

THOMAS MCKAY & Co., Ottawa, Canada.

Three Samples of Oatmeal (different Grades).

Report.—Commended for the following reasons:

1. The variety in the product, adapting it to the several forms of food made from oatmeal.
2. The cleanness of the samples, and freedom from bran or foreign substances.

H. WARTON, Guelph, Canada.

Oatmeal.

Report.—Commended for its good quality and low price.

ASPDEN & PRITCHARD, London, Canada.

Four varieties of Oatmeal.

Report.—Commended for good quality of the product, and its great variety, adapting it to several forms of food.

JAMES WILSON, Fergus, Canada.

Oatmeal.

Report.—Commended for the following reasons:

1. The sound condition of the grain.
2. Its very clean preparation.

E. D. TILSON, Tilsonsburg, Canada.

Oatmeal and Buckwheat Flour.

Report.—Commended for the excellent quality of both products, and good condition in which they were exhibited.

SCOTT & Co., Highgate, Ontario, Canada.

Four varieties of Oatmeal.

Report.—Commended for the following reasons:

1. The excellent quality of the stock from which the product was manufactured.
2. The care used in the manufacture, producing a great variety of product of excellent quality.

LAWRENCE ROSE, Georgetown, Canada.

Buckwheat Flour.

Report.—Commended for the fair colour and sound condition of the product, and its entire freedom from mustiness.

P. Francis, Brooklyn, Canada.

Oatmeal (Three samples, different varieties).

Report.—Commended for the variety of products and their uniform good quality.

Th. Rankin & Sons, St. John, New Brunswick.

Honey Biscuit.

Report.—Commended for fine quality and beautiful display.

Christie, Brown, & Co., Toronto, Canada.

Biscuit and Crackers.

Report.—Commended for general excellence.

William Smith, Fairfield Plains, Brant Co., Ontario, Canada.

Clover Seed.

Report.—Commended for the cleanliness and genuineness of "Alseke" clover seed.

T. M. Howser, Campden, Lincoln Co., Ontario, Canada.

Clover Seed.

Report.—Commended for the good appearance, uniformity, and genuineness of red clover seed.

Jas. Collins, Erin, Ontario, Canada.

Wheat.

Report.—Commended for the good condition and weight of "Rio Grande" wheat.

R. Sugg, Minto, Ontario, Canada.

Wheat.

Report.—Commended for the good condition and weight of "Scotch" wheat.

Jno. Campbell, Hullett, Ontario, Canada.

Wheat.

Report.—Commended for the fine condition and weight of "Fife" wheat.

Wm. McGill, York County, Ontario, Canada.

Wheat.

Report.—Commended for the good weight and condition of "Soules" wheat.

James Bell, Tuckersmith, Ontario, Canada.

Wheat.

Report.—Commended for the good condition and weight of "club" wheat.

William Bell, Tuckersmith, Ontario, Canada.

Wheat.

Report.—Commended for the good condition and weight of Tarrow wheat.

Robert Schearer, Niagara, Ontario, Canada.

Wheat.

Report.—Commended for the very fine condition and good weight of Delhi and Fife wheat.

MATTHEW MEARNS, Durham, Ontario, Canada.

Wheat.

Report.—Commended for good condition and weight of "Treadwell" wheat.

WM. P. O'NEAL, Watertown, Ontario, Canada.

Wheat.

Report.—Commended for good condition and weight of "Treadwell" and "white winter" wheat.

T. MANDERIM, Myrtle, Ontario, Canada.

Wheat.

Report.—Commended for the good condition of Delhi wheat, weighing sixty-five pounds per bushel.

R. MCGILL, Erin, Ontario, Canada.

Wheat.

Report.—Commended for the excellent condition and weight of "Treadwell" wheat.

W. P. HOWLAND, Toronto, Ontario, Canada.

Wheat.

Report.—Commended for the good condition and weight of "Rio Grande" wheat.

R. TUCK, Nelson, Ontario, Canada.

Wheat.

Report.—Commended for good condition of Delhi wheat, weighing sixty-three and a half pounds per bushel.

WM. BEATTIE, Nickol, Ontario, Canada.

Wheat.

Report.—Commended for fine condition and good weight of "Fife" wheat.

SAMUEL DAWES, Whitby, Ontario, Canada.

Wheat.

Report.—Commended for the excellent condition of "Delhi" wheat, weighing sixty-five pounds per bushel.

JACOB SEIP, Petersburg, Ontario, Canada.

Wheat.

Report.—Commended for the good condition and weight of "red chaff" wheat.

ALEX. STEWART, Brussels, Ontario, Canada.

Wheat.

Report.—Commended for the good condition and weight of "club" wheat.

THOS. I. SKINNER, Cowitcher, British Columbia.

Wheat.

Report.—Commended for the good condition of red chaff wheat.

INDIANS OF DOUGLASS LAKE, British Columbia.

Wheat.

Report.—Very fine sample of red chaff wheat.

MISSION OF CHIPEGAN, Lake Alataska, British Columbia.

Wheat and Barley.

Report.—Fine samples of wheat and barley raised in 58° 42′ north latitude.

JAS. H. MURTON, Salesbury, New Brunswick.

Wheat.

Report.—Commended for good weight and condition of wheat.

MRS. JANE TAYLOR, York, New Brunswick.

Oats.

Report.—Commended for the very fine appearance and weight (forty-nine pounds per bushel) of white oats.

GEORGE STONEHOUSE, Scarboro, York County, Canada.

Barley.

Report.—Commended for the very fine condition of two-rowed barley.

THOS. MANDERSON, Myrtle, Ontario, Canada.

Oats.

Report.—Commended for the good appearance and weight of "surprise" oats.

CHAS. ANDERSON, Hastings, Ontario, Canada.

Oats.

Report.—Commended for the good appearance and weight of "surprise" oats.

LAMUS SMITH, Chatham, Ontario, Canada.

Oats.

Report.—Commended for the fine appearance and weight of black oats.

C. H. MOYER, Campden, Ontario, Canada.

Bohemian Oats.

Report.—Commended for the good appearance and great weight of hull-less or Bohemian oats.

THE ADVISORY BOARD OF PRINCE EDWARD'S ISLAND, Charlottetown.

Oats.

Report.—Commended for the very fine appearance and weight of white oats.

JOHN STEWART, Horton, Renfrew, Canada.

Rye.

Report.—Commended for good appearance and weight.

R. P. Slater, Galt, Ontario, Canada.

Malt.

Report.—Commended for superior quality.

Howard & Northwood, Chatham, Canada.

Malt.

Report.—Very fine and clean.

John Labatt, London, Canada.

Malt.

Report.—Excellent in quality.

Canadian Meat and Produce Co., Sherbrooke, Quebec, Canada.

Pickles, Sauces, and Soups.

Report.—Commended for the following reasons:

1. Careful preparation.
2. Very good taste.
3. Variety.

Wm. McEvoy, Woodburn, Wentworth, Ontario, Canada.

Honey.

Report.—Commended for its full aromatic flavour and well-preserved condition.

S. Davis & Co., Montreal, Canada.

Cigars.

Report.—Well made; fine workmanship; from Havana and American tobacco.

For workmanship these cigars are equal to any on exhibition.

Wm. Dunn, Ingersoll, Ontario, Canada.

Butter.

Report.—Commended for purity of flavour and skilful manufacture; the exhibit comprising butter in tubs and in pound prints.

Michael Ballantyne, Ingersoll, Ontario, Canada.

Butter.

Report.—Commended for its fine flavour, colour, texture, and make.

Hettle & Inglis, Teeswater, Ontario, Canada.

Butter.

Report.—Fine, well-made, finely flavoured roll butter.

Mark Chalcroft, Thamesford, Ontario, Canada.

Cheese.

Report.—Commended for its full, nutty, and clean flavour, and its superior richness, fine texture, and skilful manufacture.

James Ireland, Ingersoll, Ontario, Canada.

Factory Cheese.

Report.—Commended for superior excellence in respect to flavour, richness, and texture.

PETER DUNN, Ingersoll, Ontario, Canada.
Cheese Coloured and Uncoloured.

Report.—Commended for its extraordinary high and delicious flavour, rich quality, and perfect texture.

MARK CHALCROFT, Thamesford, Ontario, Canada.
Factory Cheese.

Report.—Commended for its clean and well-developed flavour, its richness, and general excellence.

JAMES A. JAMES, Nilestown, Ontario, Canada.
Factory Cheese.

Report.—Superior in make, quality, and style.

E. N. HOPKINS, Ingersoll, Ontario, Canada.
Factory Cheese.

Report.—A superior-made, fine-flavoured, rich article.

ADAM BELL, East Zora, Ontario, Canada.
Factory Cheese.

Report.—Very fine; well made; superior flavour.

JAMES ELLIOTT, Brownsville, Ontario, Canada.
Factory Cheese.

Report.—Fine flavour; well made; superior in style.

HUGH MATHISON, Embro, Ontario, Canada.
Factory Cheese.

Report.—Finely made; fine stock; superior flavour.

THOMAS BALLANTYNE, Stratford, Ontario, Canada.
Factory Cheese.

Report.—Cheese up to highest quality in every respect.

WM. ANDERSON, Woodstock, Ontario, Canada.
Factory Cheese.

Report.—A superior sample of coloured cheese; rich, stocky, and fine nutty flavour.

O. P. MABEE, Courtland, Ontario, Canada.
Factory Cheese.

Report.—Fine flavour; well creamed; superior cheese.

GEORGE CURRIE, Beachville, Ontario, Canada.
Factory Cheese.

Report.—Very fine flavour; rich; superior stock; clean.

ALEXANDER MCKENZIE, Kastnerville, Ontario, Canada.
Factory Cheese.

Report.—Commended for perfection in all its qualities.

MARK CHALCROFT, Thamesford, Ontario, Canada.
Factory Cheese.

Report.—A very fine sample of uncoloured cheese, superior in flavour and texture.

WM. GILLARD, Tavistock, Stratford, Canada.
Factory Cheese.

Report.—Very choice quality of uncoloured cheese.

DAVID MORTON, Cassells, Canada.
Factory Cheese.

Report.—Superior sample of rich, buttery, and high-flavoured white cheese.

DAVID MORTON, Cassells, Canada.
Cheese.

Report.—Fine sample of cheese for shipping, made on the American plan.

THOMAS BALLANTYNE, Stratford, Ontario, Canada.
Cheese.

Report.—Commended for rich, buttery flavour and general excellence.

WM. HUXLEY, Fullerton, Canada.
Cheese.

Report.—Meritorious cheese for shipping purposes.

D. CHAMBERS, Stratford, Canada.
Cheese.

Report.—A fine sample of factory cheese for shipping.

HUGH MATHISON, Embro, Canada.
Cheese.

Report.—A sample of shipping cheese, of superior merit.

JOHN BUTLER, Mount Elgin, Canada.
Cheese.

Report.—Fine sample of cheese for shipping purposes.

I. W. CAHOE, Durham, Canada.
Cheese.

Report.—A sample of shipping cheese, of superior merit.

D. B. CAHOE, Holbrook, Canada.
Cheese.

Report.—A sample of shipping cheese, of superior merit.

MARK CHALCROFT, Thamesford, Canada.
Coloured Cheese.

Report.—Commended for fine flavour, texture, and colour.

ADAM BELL, Blanford, Canada.

Pale Cheese for Shipping.

Report.—Commended for superior texture and flavour; the best sample of pale cheese of fifty to seventy-five pounds' weight shown at August exhibit.

WM. MANNING, Belmont, Ontario, Canada.

Coloured Cheese.

Report.—Commended for superior flavour, texture, and colour.

ADAM BELL, Blanford, Canada.

Uncoloured Cheese.

Report.—Commended for its full and pure flavour, its richness and excellence in all respects.

DAVID CHALMERS, Stratford, Canada.

Factory Cheese.

Report.—A very choice quality of uncoloured cheese; two exhibits.

ADAM E. BELL, Gorra and Blandford, Innerkip, Canada.

Cheese.

Report.—The best cheese of thirty to fifty pounds at the special exhibition of dairy products, June 26 to July 6, of Canadian make.

PETER DUNN, Ingersoll, Ontario, Canada.

Cheese.

Report.—Well made; fine in flavour.

THOMAS HANKINS, Holbrook, Ontario, Canada.

Cheese.

Report.—The best sample of cheese of dairy manufacture shown at special exhibition of dairy products, June 26 to July 6.

ROBERT AGUR, Pond Mills, Ontario, Canada.

Coloured Cheese.

Report.—Commended for superior flavour, texture, and colour.

WM. ANDERSON, Woodstock, Canada.

Cheese.

Report.—A sample of shipping cheese, of superior merit.

PETER DUNN, Ingersoll, Canada.

Cheese.

Report.—A fine sample of cheese for shipping purposes.

GEORGE SMITH, Verschoyle, Canada.

Cheese.

Report.—A sample of shipping cheese, of superior merit.

JAMES IRELAND, Ingersoll, Ontario, Canada.

Cheese.

Report.—A fine sample of cheese for shipping purposes.

E. Caswell, Ingersoll, Ontario, Canada.

Cheese Truckle.

Report.—The best cheese of three to ten pounds at the special exhibition of dairy products, June 26 to July 6.

P. Hemmingway, Corinth, Ontario, Canada.

Cheese.

Report.—The best cheese of fifty to seventy pounds' weight presented at the special exhibition of dairy products, June 26 to July 6, of factory make.

James Ireland, Ingersoll, Ontario, Canada.

Factory Cheese.

Report.—Finely made, clean and superior.

Peter Dunn, Ingersoll, Canada.

Factory Cheese.

Report.—The best three cheeses made on the American factory plan, in June, July, August, and September, respectively, according to schedule of June 15, 1876.

James A. Robins, Avon Factory, Avon, Canada.

Cheese.

Report.—Commended for fine quality as shipping cheese.

Anna Paddon, Beachville, Canada.

Cheese.

Report.—A sample of shipping cheese, of superior merit.

E. Hunter, Mount Elgin, Canada.

Cheese.

Report.—A sample of shipping cheese, of superior quality.

H. S. Losee, Norwich, Canada.

Cheese.

Report.—A sample of shipping cheese, of superior merit.

H. S. Losee, Norwich, Ontario, Canada.

Factory Cheese.

Report.—Commended for its superior excellence in regard to flavour, richness, and skilful manufacture.

William Wilkinson, Ingersoll, Ontario, Canada.

Coloured Cheese.

Report.—Commended for superior flavour, colour, and texture.

William Wilkinson, Ingersoll, Ontario, Canada.

Cheese.

Report.—A sample of great merit as shipping cheese.

William Wilkinson, Ingersoll, Ontario, Canada.

Cheese.

Report.—Commended for its clean and pure flavour, its great richness, and general excellence.

J. F. Williams, Galloway, Ontario, Canada.

Pale Cheese for Shipping; from Fifty to Seventy Pounds' Weight.

Report.—Commended for superior texture and purity of flavour; a very choice sample.

J. F. Williams, Galloway, Ontario, Canada.

Uncoloured Cheese.

Report.—Commended for its full, nutty, and pure flavour, and its superior richness, fine texture, and excellent make.

James J. Williams, Galloway, Ontario, Canada.

Cheese.

Report.—A sample of shipping cheese, of superior merit.

John Chisholm, East Nissouri, Ontario, Canada.

Coloured Cheese.

Report.—Commended for superior flavour, texture, and colour.

John Chisholm, East Nissouri, Ontario, Canada.

Coloured Cheese.

Report.—Commended for its full, nutty, and pure flavour, and its superior richness and compact texture and excellent make.

John Chisholm, Ingersoll, Ontario, Canada.

Factory Cheese.

Report.—Fine, rich, good style; superfine flavour.

J. W. Butcher, Halifax, Nova Scotia.

Preserved Fruits (Strawberries and Cranberry Jelly).

Report.—Fruits good and well preserved.

R. B. Noble, Richibucto, New Brunswick.

Preserved Blueberries.

Report.—The fruit is fresh and the flavour good.

Christian Netz, Halifax, Nova Scotia.

Bologna preserved in Lard.

Report.—Commended for the following reasons:

1. Good taste.
2. Good preservation.

W. Woodrell, Halifax, Nova Scotia.

Mess Beef.

Report.—The meat is carefully packed, and is in an excellent state of preservation.

Canadian Meat and Produce Co., Sherbrooke, Canada.

Canned Meat in great variety.

Report.—Commended for the following reasons:

1. The great variety exhibited; to wit, ox-tongue, whole, in can; game pie, in can; roast chicken, whole, in can; roast duck, whole, in can; roast veal, venison, and beef, in cans; pork truffles, in cans; sausages, in cans.
2. The uniform good quality of the meats exhibited.

J. D. Brian, Restigouche, New Brunswick.

Canned Roast Beef.

Report.—Commended for the excellent preservation of the peculiar flavour of the fresh beef.

Christian Netz, Halifax, Nova Scotia.

Smoked Goose, Ham, Ox-Tongue, and Sausage.

Report.—Commended for the following reasons:

1. Novelty and variety of the exhibit.
2. Good quality of meat.

E. Caswell, Ingersoll, Ontario, Canada.

Cured Hams and Bacon.

Report.—A superior manner of curing, which secures long keeping and the finest flavour.

E. Caswell, Ingersoll, Ontario, Canada.

Hams, Breakfast Bacon, Smoke-dried Sides, and Prime Mess Pork.

Report.—Commended for the following reasons:

1. The excellent state of preservation in which all the articles were found.
2. The fine flavour and colour of the meat.

James Knight, Halifax, Nova Scotia.

Brandy of Cherry.

Report.—Very good brandy, well prepared; agreeable bouquet and well conditioned.

Wine Growers' Association, Toronto, Ontario, Canada.

Wine and Brandy.

Report.—Very good wine, of fine bouquet, excellent quality, and very well prepared. The brandy is very fine, and has a particularly good taste.

John Labatt, London, Ontario, Canada.

Ale and Stout.

Report.—A variety of ale and stout. The latter, labelled XXX, was first-rate; the India pale ale, well brewed and very good; the ale on draught, well fermented and very good.

Thos. Davies & Brother, Toronto, Ontario, Canada.

Ale and Porter.

Report.—A variety of brewings of ale and porter, of which the cream ale on draught was very good; the draught ale, very fair; the draught porter, good; and the cream crystal ale in bottles, fair.

Cosgrove & Co., Toronto, Ontario, Canada.

Bottled Ale.

Report.—Excellent in colour and brightness; very good in aroma and taste.

V. Casci, St. Vincent, Toronto, Canada.

Cherry Wine.

Report.—Good quality, fine bouquet, and carefully prepared.

AGNEW L. FARRELL, Cayuga, Ontario, Canada.

Hermitage Wines.

Report.—Very good wine with very fine bouquet; of good quality, and well conditioned.

JAMES HUSTINGS, White Church, Canada.

Wine.

Report.—Of good quality, excellent bouquet, and kept in very good condition.

D. NIXON, Allisonville, Ontario, Canada.

Wine.

Report.—Good sweet wine of excellent quality, delicious flavour, and very well conditioned.

GROUP V.—FISH AND FISH PRODUCTS, APPARATUS OF FISHING, &C.

JAMES BARBER, Halifax, Nova Scotia.

Canned Lobster and canned Mackerel.

Report.—Commended for good preparation.

J. D. BAIN, Restigouche, New Brunswick.

Canned Mackerel, canned Lobster, and canned Salmon.

Report.—Commended for excellence of preparation.

A. S. CROWE, Halifax, Nova Scotia.

Salted and dried Haddock, salted Hake, salted Pollock, and smoked Herring.

Report.—Commended for great excellence in all the preparations in the exhibit.

HOLBROOK & CUNNINGHAM, Victoria, British Columbia.

Canned Salmon.

Report.—Commended for great excellence in preparation, the salmon retaining its form, taste, and colour.

A. LOGGIE & Co., New Westminster, British Columbia.

Salted Salmon, Trout, and Oolachan, in barrels and kits.

Report.—Commended for excellent preparation, having withstood the heat; sound and well flavoured.

ANDREWS & Co., Halifax, Nova Scotia.

Canned Lobster and Mackerel.

Report.—Commended for good preparation.

CHIBUCTO PACKING Co., Halifax, Nova Scotia.

Canned Lobster.

Report.—Commended for excellence in preparation.

EWING & WISE, Victoria, British Columbia.

Isinglass.

Report.—Commended for good preparation.

Canada.

Group V.

R. B. Noble, Richibucto, New Brunswick.

Canned Lobster.

Report.—Commended for good preparation.

T. Doyle, Halifax, Nova Scotia.

Tongues, Sounds, Herrings, and Mackerel.

Report.—Commended for excellence of preparation, the product in barrels having kept sweet and in a sound condition during an exceptionally hot summer.

D. Scribner, St. John, New Brunswick.

Rods for catching Salmon.

Report.—Commended as well made and serviceable.

Educational Department, Toronto, Ontario, Canada.

Prepared Fish.

Report.—Commended as well prepared.

Group VI.

Group VI.—Timber, Worked Lumber, Parts of Buildings, Forestry.

Wilson, Gilmour, & Co., St. John, New Brunswick, Canada.

Marbleized Slate Mantels.

Report.—Commended for good taste of design and good workmanship.

Charles Hendry, Conestoga, Ontario, Canada.

Linseed.

Report.—Commended for excellence and purity of the exhibit.

Advisory Board of Manitoba, Manitoba, British America.

Seeds, Wild Hops, and Wild Tea.

Report.—The exhibit is not a large one, but it is of much interest, because of the locality and the nature of the products.

Advisory Board of Ontario, Ontario, Canada.

Sundry Seeds, other than Cereals.

Report.—Commended for the excellence and variety of the exhibit, which contains more than seventy exhibits of peas, besides many of beans and linseed, many of special excellence; the exhibit in peas, beans, and linseed being of special excellence.

Council of Agriculture of Quebec, Montreal, Canada.

Sundry Field Seeds.

Report.—A nice exhibit of beans, peas, and linseed.

John Rochester, Ottawa, Canada.

Pine Lumber.

Report.—Commended for extent and general good quality.

Perley & Pattee, Ottawa, Ontario, Canada.

Pine Lumber.

Report.—Commended for size, good quality, and variety.

GEORGE NEWELL, Ottawa, Ontario, Canada.

Ash Pillars.

Report.—Commended for the beauty of material and good workmanship displayed.

WM. RENNIE, Toronto, Canada.

Garden and other Seeds.

Report.—The exhibit is not large (about one hundred kinds), but the samples are in especially good condition.

ADVISORY BOARD OF NOVA SCOTIA, Halifax, Nova Scotia.

Various Seeds, other than Cereals.

Report.—Commended for the excellence of the exhibit.

ADVISORY BOARD OF NOVA SCOTIA, Halifax, Nova Scotia.

Exhibit of Seeds.

Report.—Linseed and other seeds in the collective exhibit, which contains much not referred to this group; the linseed recommended for excellence. The collective exhibit of seeds and grains is generally good.

J. H. ALLEN, Pictou, Prince Edward's County, Ontario, Canada.

Fifteen Varieties of Peas.

Report.—The exhibitor has made a specialty of this crop, and the exhibit is specially meritorious in variety and quality.

G. B. HALL, Montmorency Mills, Quebec, Canada.

Pine Boards.

Report.—A fine exhibit of wide, clear pine boards.

H. P. CUSACK, Newbury, Ontario, Canada.

Barrel Hoops.

Report.—Commended for the excellence of material and good workmanship displayed.

LEVI YOUNG, Ottawa, Ontario, Canada.

Pine Lumber.

Report.—A large exhibit of fine stock-boards.

A. N. GREIG, Montreal, Quebec, Canada.

Painted Imitations of Wood and Marbles.

Report.—Commended for the excellence of the imitation, that of the woods being specially good.

BRONSON J. WESTON, Ottawa, Ontario, Canada.

Pine Lumber.

Report.—Commended for size and quality.

PIKE & RICHARDSON, Chatham, Ontario, Canada.

Barrel Hoops.

Report.—Commended for good quality of material and good workmanship.

Canada.
Group VI.

QUEBEC ADVISORY BOARD, Montreal, Quebec, Canada.

Worked Lumber.

Report.—Commended for the variety of the exhibit and the fine quality of the lumber shown.

JOHN OLIVER, Toronto, Ontario, Canada.

Worked Lumber.

Report.—Commended for variety and excellence.

FAIRBANKS & HAWES, St. John, New Brunswick, Canada.

Doors, Sashes, Blinds, and Newel Posts.

Report.—Commended for good material used in construction, for excellent workmanship, and for moderate prices.

Group VII.

GROUP VII.—FURNITURE, UPHOLSTERY, WOODEN WARE, BASKETS.

WM. LEE, Toronto, Ontario, Canada.

Furniture.

Report.—Commended for an inlaid table, well made, good finish, and perfect workmanship.

JOSEPH ROY & Co., Montreal, Canada.

Invalid-Chair.

Report.—Commended for the facility with which it can be changed from a horizontal to an upright position, and for adaptability for the sick-room.

Q. W. TUERK, Berlin, Ontario, Canada.

Clock Case, and Chandeliers in Oak.

Report.—Commended for an ornamental design, well carved.

J. WRIGHT, Montreal, Canada.

Parquetry Flooring.

Report.—Commended for good taste, design, and workmanship, at low price, and very fine display.

Group VIII.

GROUP VIII.—COTTON, LINEN, AND OTHER FABRICS.

DUNDAS COTTON MILLS, Hamilton, Ontario, Canada.

Heavy brown Sheetings and seamless Bags.

Report.—The sheetings are very even, firm, and very clean, and the bags are of a very superior quality.

S. S. FULLER, Stratford, Ontario, Canada.

Flax.

Report.—Commended for good quality and long staple.

Group IX.

GROUP IX.—WOOL AND SILK FABRICS, WITH THE MACHINERY.

A. L. WOODWORTH, St. John, New Brunswick.

Woollen Yarns.

Report.—A considerable variety of woollen yarns, in good colours, and well adapted for the purpose intended.

H. Winger, Elmira, Ontario, Canada.

Flannels.

Report.—Serge flannel cotton wool blankets; excellent for the price.

Smith & Wilby, Toronto, Ontario, Canada.

Flannels.

Report.—Three-quarters domestic flannels, at low cost, for general use.

Oxford Woollen Mills, Oxford, Nova Scotia.

Woollens.

Report.—Wool flannels, Halifax tweeds, and home-spun stuff; all excellent goods for general use.

John Wardlaw, Galt, Ontario, Canada.

Woollen Yarns.

Report.—White, coloured, and grey knitting yarns, in considerable variety of shades, cheap, useful, and well adapted for general use.

Rosamond Woollen Co., Almonte, Ontario, Canada.

Woollens.

Report.—Fancy cassimeres and tweeds, of excellent manufacture and low cost.

Mills & Hutchison, Montreal, Quebec, Canada.

Woollens.

Report.—Three-quarters cassimeres and Canadian tweeds, of excellent manufacture and good value.

Adam Lomas & Son, Sherbrooke, Quebec, Canada.

Flannels.

Report.—Very cheap flannels, cloths, and tweeds, well adapted for general consumption.

Samuel T. Willett, Chambly, Quebec, Canada.

Flannels.

Report.—Blue, scarlet, and mixed flannels, of rich colour and soft texture, all excellent for the price.

John Harvie & Co., Hamilton, Ontario, Canada.

Wool.

Report.—A very complete and creditable exhibit of Leicester, Cotswold, and Southdown wool; also the following crosses: Leicester and merino, Leicester and Southdown, Cotswold and Leicester, Lincoln and Cotswold, Leicester and Cotswold. The Southdown and Leicester merino are excellent both in staple and fibre, also the Leicester and Southdown cross good; the others fair.

Toronto Tweed Co., Toronto, Ontario, Canada.

Woollens.

Report.—Fancy Scotch tweeds, plaids, and cheviots, in novel patterns, and at reasonable prices.

Canada.
Group IX.

T. S. Fisher, Toronto, Ontario, Canada.

Woollens.

Report.—Cheviot coatings, meltons, tweeds, and Blair Athols, all of useful manufacture and at low prices.

S. H. Powers, Woodstock, New Brunswick.

Hand Loom.

Report.—A useful hand loom for domestic purposes.

Group X.

Group X.—Clothing Furs, India-rubber Goods, Ornaments and Fancy Articles.

T. G. Furneval, Canada.

Clothing.

Report.—Commended for skill in cut, appropriateness, taste in trimming, and good workmanship.

R. F. Taylor & Son, Toronto, Ontario, Canada.

Men's Clothing.

Report.—Commended for fair skill in cut, and durable workmanship.

J. S. May, St. John, New Brunswick.

Clothing for Gentlemen.

Report.—Commended for good material, fair skill in cut, and good workmanship.

T. Turnbull, Galt, Ontario, Canada.

Knitted Underwear.

Report.—Commended for excellence in colour, and high grade of fabric.

McCrae & Co., Guelph, Ontario, Canada.

Knit Goods and Hosiery.

Report.—Commended for excellence of material used, and special adaptability to home markets, and cold climates generally.

Ancaster Knitting Co., Hamilton, Ontario, Canada.

Knitted and Fancy Goods.

Report.—Commended for the large and varied assortment, and skill displayed in colour and finish.

Brown & Clagget, Montreal, Canada.

Costumes for Ladies.

Report.—Commended for variety in design, taste in trimmings, and as being well made.

Skelton Tooke & Co., Montreal, Canada.

Shirts, Collars, and Cuffs.

Report.—Commended for variety in design, good quality of the material used, good work, and economy in cost.

Mrs. R. A. Wicksteed, Ottawa, Canada.
Point Laces.
Report.—Commended for great excellence in taste and workmanship.

Miss Sidney Smith, Dundas, Canada.
Lace Work Handkerchief.
Report.—Commended for excellent taste and fine workmanship.

Mrs. Nunn, Belleville, Canada.
Point Lace.
Report.—Commended as tasteful in design and excellent in workmanship.

Miss Isabella Fairbanks, Halifax, Nova Scotia.
Lace Handkerchief.
Report.—Commended for good taste and very fine workmanship.

Grey Nuns of Montreal, Montreal, Canada.
Embroidered Handkerchief.
Report.—Commended for great skill in workmanship.

Hochelaga Convent, Montreal, Canada.
Embroidery—Priests' Vestments.
Report.—Commended for great excellence in design and workmanship.

Convent Jesus and Mary, Quebec, Canada.
Embroidery—Priests' Vestments.
Report.—Commended for great excellence in design and workmanship.

Mrs. De B. McDonald, Montreal, Canada.
Gobelin Tapestry.
Report.—Commended for great excellence in taste, skill, and workmanship.

Mrs. Sutcliffe, Halifax, Nova Scotia.
Needlework—"Last Supper."
Report.—Commended for superior skill and workmanship.

The Misses Farrell, Halifax, Nova Scotia.
Fancy Wool Work.
Report.—Commended for very good taste and great skill in execution.

Miss Park, Watertown, Canada.
Knitting and Tatting.
Report.—Commended for great taste and skill in workmanship.

General Hospital, Quebec, Canada.
Artificial Flowers.
Report.—Commended for a great display of artistic taste and skill.

Miss Lizzie Farquharson, Whitby, Canada.

Painting on Velvet, Designs for Painting.

Report.—Commended for artistic taste and skill in designs.

Reynolds & Völkel, Montreal, Canada.

Wolf Robes and Rugs.

Report.—Very fair wolf robes and rugs, ladies' musk-rat pelerines, caps, muffs, gauntlets, Indian buckskin leggings and hunting overcoats, all in great and handsome variety. Commended for quality and fitness for use.

Hudson Bay Co., Montreal, Canada.

Raw Furs and Esquimaux Sealskin Coat.

Report.—A fine display of raw furs, white bear, brown and black bear, mink, lynx, white, gray, and blue wolf, beautiful red, silver, and cross fox, and other fine varieties of skins. There is to be mentioned also a very fair Esquimaux sealskin coat, and dressed reindeer skins. Commended for great variety and superior quality of furs.

Thibault, Lanthier, & Co., Montreal, Canada.

Furs, Ermine, and Muffs.

Report.—Two splendid cases of furs, ermine muffs, silk muffs with trimmings of ermine, Northshore otter coat for gentlemen, South Sea seal sacks, Northern Canada mink sacks, blue and silver raccoon, ladies' velvet bonnets, grebe and silver-pointed sea-otter muffs, silk opera cloak lined with royal ermine, and a beautiful variety of other skins. Commended for quality, taste, cheapness, and superior workmanship.

C. Kaiser & Son, Halifax, Canada.

Natural Raccoon and Black-Bear Robes.

Report.—Splendid natural raccoon and black-bear robes, red, blue, and cross fox skins, musk-rat and Canada mink muffs and boas, and sealskin sacks. Commended for good patterns and fine workmanship.

Miss Kate Farrell, Toronto, Ontario, Canada.

Carriage Rug of Worsted Yarn.

Report.—Commended for skill and taste, both in colour and design.

Mrs. Constant, Halifax, Nova Scotia.

Leather Work for Mirror-frame.

Report.—Commended for excellence in tasteful design and great skill in execution.

Mrs. Neville, Ottawa, Canada.

Leather Work.

Report.—Commended for artistic skill and taste in design and execution.

W. E. Clarke, Toronto, Ontario, Canada.

Trunks, Valises, Bags of Calf Leather and Wood, with Nickeled Iron Buckles.

Report.—Commended for fitness and quality as well as cheapness; also for fine workmanship and good appearance.

G. R. Grind, London, Ontario, Canada.

Corn Brooms and Whisks.

Report.—Commended for excellent quality, great variety, very low prices, fitness, and workmanship.

C. Boeck, Toronto, Ontario, Canada.

Brushes.

Report.—A very good set of hair and painting brushes, horse brushes, well made and durable; also an improvement in hair brushes, for regulating the softness and stiffness of the brush. Commended for general quality and novelty.

Whitehead & Turner, Quebec, Canada.

Brushes of all kinds.

Report.—Commended for excellent quality and moderate prices.

Group XII.—Leather and Manufactures of Leather.

Heath & Northey, Montreal, Canada.

Hemlock Sole Leather.

Report.—Commended for high excellence in skill and workmanship throughout in the manufacture of the leather.

David Ramsey, Cobourg, Ontario, Canada.

Gentlemen's Hand Custom-made Boots and Shoes.

Report.—A small but very handsome exhibit of patent, calf, button, and Congress gaiters, high lace, bellows tongue, double inseam cork sole shoe, calf button gaiters. Very superior workmanship and material, with excellent taste and fitting proportions.

Mosely & Ricker, Montreal, Canada.

Grain, Buff, and Split Leather.

Report.—Commended for general good skill in the manufacture throughout.

Wm. Craig & Son, Port Hope, Ontario, Canada.

Tanned and Finished Sheep and Roans.

Report.—This exhibit comprises saddlers' russets, wood, red, and maroon roans and law sheep; is well tanned and finished; uniform and clear colours. The law sheep is specially fine and well finished.

Group XIII.—Paper, Stationery, Printing, and Bookmaking.

Canada Paper Co., Montreal, Canada.

Paper.

Report.—This is an exhibit of printing, envelope, blotting, and wrapping papers; all of good quality in their respective classes.

Louis Perrault & Co., Montreal, Quebec, Canada.

Commercial Printing.

Report.—Commended for great variety and good quality of the work exhibited and its adaptation to public wants.

Canada.
Group XIII.

SAINT CROIX RIVER MILLS, Saint Croix, Nova Scotia.

Binders' Pasteboard.

Report.—Commended for the good quality of binders' board, at a low price.

Group XIV.

GROUP XIV.—APPARATUS OF HEATING, LIGHTING, VENTILATION, WATER SUPPLY, DRAINAGE, &c.

ALEXANDER ANDERSON, Canada.

Bread-knife.

Report.—Recommended for the following reasons:—

1. A ragged-edge knife, moving in a graduated groove, and slicing bread with great rapidity and precision of any width.
2. Its cheapness, simplicity, and durability.

JAMES MCELVEY, St. Catherine's, Canada.

Cream Gatherer.

Report.—Commended as an ingeniously devised and valuable means of preserving milk and cream in sweetness and purity.

Group XV.

GROUP XV.—BUILDER'S HARDWARE, TOOLS, CUTLERY, &c.

DATES PATENT STEEL CO., Toronto, Ontario, Canada.

Axes and Edge Tools.

Report.—Commended as of excellent quality and styles.

PETER ROBERTSON, Ottawa, Ontario, Canada.

Lumbermen's and Stonecutters' Tools.

Report.—Commended as of good quality and serviceable tools.

THOMAS MOORE, Cooksville, Ontario, Canada.

Axe and Tool Handles.

Report.—Commended as of excellent material and well made.

R. H. SMITH & CO., St. Catherine's, Ontario, Canada.

Saws.

Report.—Commended for the good quality and finish of their exhibit of mill, cross-cut, circular, and other heavy saws; also for their hand-saws, buck-saws, and trowels.

SPILLER BROS., St. John, New Brunswick, Canada.

Edge Tools.

Report.—Commended for quality and finish.

JOSEPH WARNOCK & CO., Galt, Ontario, Canada.

Axes and Edge Tools for Wood, Iron, and Stone.

Report.—Commended as of excellent design and superior workmanship.

AHEARN & WALSH, Ottawa, Canada.

Lumbermen's Tools.

Report.—Commended as of good quality.

A. S. WHITING MANUFACTURING Co., Oshawa, Ontario, Canada.

Forks, Hoes, Scythes, and Straw Knives.

Report.—Commended as of the highest quality; also patterns and finish highly commended.

STAR MANUFACTURING Co., Halifax, Nova Scotia.

Skates.

Report.—Commended as of excellent quality and finish.

S. R. FOSTER & SON, St. John, New Brunswick, Canada.

Nails, Tacks, and Brads.

Report.—Commended as well made and fair merchantable goods.

PILLOW, HERSEY, & Co., Montreal, Quebec, Canada.

Nails, Tacks, Brads, and Horseshoes.

Report.—Commended as of superior quality.

G. GILMORE, Côte St. Paul, Quebec, Canada.

Augers and Bits.

Report.—Commended as of superior style and finish.

GROUP XVII.—CARRIAGES, VEHICLES, AND ACCESSORIES.

WM. KEW & SON, Beamsville, Ontario, Canada.

Two-seat Dog-cart Sleigh.

Report.—Commended as well built and well suited to the purpose for which it is intended, and offered at a remarkably low price.

B. LEDOUX, Montreal, Canada.

Seven-passenger Sleigh.

Report.—By means of a sliding arrangement under the front seat, the capacity of this sleigh may be reduced at pleasure to five instead of seven. It is quite ingenious, and well and substantially built.

JOHN M. DE WOLFE, Halifax, Nova Scotia.

Three Light Carriages.

Report.—General sound work and good finish; the more commendable when the lack of facilities for carriage-building in Halifax is taken into consideration.

HUNT, CAIRNS, & Co., St. Catherine, Ontario, Canada.

Wheels and Wheel Stock.

Report.—Commended for good material and workmanship.

S. & H. BORBRIDGE, Ottawa, Ontario, Canada.

Harness and Saddles.

Report.—The saddles are well made, of good material, and display good workmanship.

Canada.

ROBERT MALCOM, Toronto, Ontario, Canada.

Group XVII. *One Set Extra Large and Heavy Dray Harness finished for Display; One Set Extra Large and Heavy Dray Harness finished for Work; Ten Ladies' and Gentlemen's Saddles of various Weights and Patterns.*

Report.—Commended as fine substantial work and well adapted to the intended uses.

WM. VAHEY, Forrest, Ontario, Canada.

Horse Collars and Collar Block.

Report.—The collar block is a good, useful, and economical article.

DANIEL CONBOY, Uxbridge, Ontario, Canada.

Sleigh.

Report.—Commended for originality and good workmanship.

Group XVIII. GROUP XVIII.—RAILWAY PLANT, ROLLING STOCK AND APPARATUS, ROAD ENGINES.

TORONTO CAR WHEEL CO., Toronto, Canada.

Car Wheels of Chilled Iron.

Report.—Commended for successful application of the material.

MCDOUGALL & CO., Montreal, Canada.

Chilled Iron Car Wheels.

Report.—Commended for excellence of material and workmanship.

Group XIX. GROUP XIX.—VESSELS AND APPARATUS OF TRANSPORTATION NOT INCLUDED IN OTHER GROUPS.

D. HERALD, Gore's Landing, Ontario, Canada.

Hunting Canoes.

Report.—Commended for novelty of constructing without frames in the patent canoe, and for lightness, strength, and good workmanship of the ordinary hunting canoe.

WILLIAM ENGLISH, Peterborough, Ontario, Canada.

Hunting Canoe.

Report.—Commended for strength, lightness, and good workmanship.

COLDBROOK ROLLING MILLS CO., St. John, New Brunswick.

Iron Ship Knees.

Report.—Commended for good proportions and workmanship.

Group XX. GROUP XX.—MOTORS, HYDRAULIC AND PNEUMATIC APPARATUS.

A. A. MURPHY, Montreal, Canada.

Pneumatic Fire Extinguisher.

Report.—Simple, cheap, and effective apparatus easily managed.

WM. KENNEDY & SONS, Owen Sound, Ontario, Canada.

Water Wheel.

Report.—Commended for good workmanship.

BARBER & HARRIS, Meaford, Ontario, Canada.

Water Wheel.

Report.—Commended for good workmanship.

JOHN RITCHIE & SON, Toronto, Ontario, Canada.

Cocks, Valves, and Lubricators.

Report.—Commended for good workmanship.

DIXON, SMITH, & CO., Toronto, Ontario, Canada.

Leather Belting.

Report.—Commended for the excellent finish and good construction of the belting exhibited, which appears to have been made from hemlock-tanned leather.

BOWES & SON, Stratford, Ontario, Canada.

Force Pumps.

Report.—Commended for ingenuity as to combination of the material used in the construction.

M. E. DAILEY, Ottawa, Ontario, Canada.

Telescope Trestle.

Report.—Commended for the facility with which the height of the trestles may be changed to adapt them to the location and work.

SMALL & FISHER, Woodstock, New Brunswick.

Barrel Lifter.

Report.—This is a simple and efficient apparatus, and consists of a hoop hinged at opposite points, with intermediate handles.

S. WEBSTER, St. Catharine's, Ontario, Canada.

Oil Storing Tank.

Report.—The exhibit furnishes an ingenious, safe, and convenient means of storing and drawing explosive oils.

GEO. BRUSH, Montreal, Canada.

Steam Engine.

Report.—The hoisting steam engine on wheels is in plan, materials, and workmanship of good and substantial character.

JAMES MORRISON, Toronto, Ontario, Canada.

Steam Vacuum and Hydraulic Gauges.

Report.—Having exhibited manometers of solid construction and good workmanship.

GEORGE FLEMING & SONS, St. John, New Brunswick.

Oscillating Engine.

Report.—The exhibit presents an oscillating engine of good material and workmanship.

ROBERT BUSTIN, St. John, New Brunswick.

Fire Escape.

Report.—Commended as simple, useful, and reliable.

OAKVILLE MANUFACTURING CO., Oakville, Ontario, Canada.

Pumps.

Report.—The exhibits are good examples of their class.

H. W. COX, Peterborough, Ontario, Canada.

Rotary Force Pumps.

Report.—Commended for good workmanship.

ROBERT PATRICK, Galt, Ontario, Canada.

Rotary Pump.

Report.—Commended for good design.

JOHN D. RONALD, Chatham, Ontario, Canada.

Steam Fire Engine.

Report.—Commended for durability, simplicity, good workmanship, and efficiency.

WILSON, CLARK, & Co., Yarmouth, Nova Scotia.

Ship Pump.

Report.—Commended for accessibility of valves.

C. C. JONES, Fredericton, New Brunswick.

Barrel Pump.

Report.—The exhibit shows an efficient combination of wood and iron in the construction of pumps.

F. W. TUERK, Berlin, Ontario, Canada.

Working Model Water Wheel.

Report.—Commended for economy in the use of water where small amount of power is required.

JOHN DATE, Montreal, Canada.

Diving Apparatus.

Report.—The work is substantial, and the details are well designed to secure efficiently the purposes intended.

C. BARNS, Sacksville, New Brunswick.

Rotary Pump.

Report.—Commended as a good specimen of its kind.

WATEROUS ENGINE WORKS CO., Brandsford, Ontario, Canada.

Steam Engine Driving a Circular Saw.

Report.—Commended for very simple and convenient construction of the engine, which drives directly the shaft of the circular saw, reliable workmanship, and fitness for the proper purpose intended.

GOLDIE & MCCULLOCH, Galt, Ontario, Canada.

Turbine Water Wheel and Steam Engine.

Report.—Turbine water-wheel commended for excellent workmanship. The steam engine exhibited is of a very substantial, solid character, and shows plain and careful workmanship.

THE THOMSON & WILLIAMS MANUFACTURING CO., Stratford, Ontario, Canada.

Stationary Engine.

Report.—The engine exhibited is on well-approved plan, and in material and workmanship of excellent character.

GEO. FLEMING & SONS, St. John, New Brunswick.

Oscillating Steam Engine.

Report.—The oscillating engine exhibited is on well-approved plans, and is of good material and workmanship.

GROUP XXI.—MACHINE TOOLS FOR WOOD, METAL, AND STONE.

R. H. SMITH & CO., St. Catharine's, Ontario, Canada.

Circular Saws.

Report.—Beautiful circular saws, of high finish.

MITCHELL & TAPLE, Harriston, Ontario, Canada.

Wood-sawing Machine.

Report.—This machine is commended for its simplicity, handiness, and portability, as one horse power drives it. It is used with advantage in remote places for cutting stove wood and shingle baulks out of round logs.

WATEROUS ENGINE WORKS CO., Brantford, Ontario, Canada.

Portable Saw-mill.

Report.—A portable saw-mill of good construction, most conveniently arranged for portability, and from the manner in which it has been designed this saw-mill is not expensive.

J. F. FISHER & CO., Kincardine, Ontario, Canada.

Clipping Boiler-plate Machine.

Report.—This firm exhibits two machines which are similar but on different patterns. They are simple, very handy, and can be operated by the most inexperienced workman; besides which they may be commended for their powerful effects and for the quality of work produced.

MCKECHNIE & BERTRAM, Dundas, Ontario, Canada.

Wood-moulding Machine and Radial Drill.

Report.—A variety of machine tools for the working of metal and wood; also originality shown in the design of a radial drilling machine, whereby the spindle may be placed at any angle within certain limits; likewise for general convenience and soundness of structure in a machine for planing wood, which is a remarkably good tool for its intended purpose.

R. MITCHELL & CO., Montreal, Canada.

Lead Tube Bending Machine.

Report.—Commended for ingenuity and originality in the design of a machine for the formation of bends and crooks in lead pipes.

Canada.

Group XXI.

BROWNE & HOWE, St. John, N.B., Canada.

Turning Lathe.

Report.—The machine shows an ingenious, simple, and new disposition of the working tools, with rapid and various effects.

WILLIAM M. KENNEDY & SONS, Owen Sound, Ontario, Canada.

Facing and Jointing Machine.

Report.—A machine which is simple and handy, and gives good results as to the character of the work performed.

Group XXII.

GROUP XXII.—MACHINES, &C. USED IN SEWING AND MAKING CLOTHING.

R. M. WANZER & Co., Hamilton, Canada.

Lock-stitch sewing Machines.—A Shuttle sewing Machine employing a rotating Shaft in the overhanging Arm and driving the Needle-bar through a Link and trammel movement placed eccentrically to the Disc at the end of the Shaft, a Shuttle moved parallel with the direction of the feed by a Crank on a rocking Shaft, and a four-motioned feed.

Report.—Commended for quality of work performed, and for workmanship.

WILKIE & OSBORN, Guelph, Canada.

A sewing-machine Treadle made adjustable in the arc of a Circle to adapt it to the requirements of different Operators.

Report.—Commended for simplicity and adaptability.

Group XXIII.

GROUP XXIII.—AGRICULTURAL MACHINES, IMPLEMENTS OF AGRICULTURE, HORTICULTURE, AND GARDENING.

MASSEY MANUFACTURING Co., Newcastle, Ontario, Canada.

Sharpe's Patent Dumping Horse Rake.

Report.—Commended as a reliable, well-made horse rake, with simple and efficient dumping appliance, effected by break bands on the axles of both driving wheels tightened by foot leverage through connecting rods. The rakes or tines are coiled round the wooden axle, which is four inches in diameter. This secures a firm attachment, but is not the most convenient arrangement for removing the teeth.

ROWLAND DENNIS, London, Ontario, Canada.

Potato Digger and Ridging Plough combined.

Report.—Commended for a combined machine adapted by an easy change to perform three several functions. As a potato digger the plough point and share upturns the potatoes, which are separated from the earth by a series of fingers or prongs projecting back on each side. Attached to the share, this point and share are removable. Another and smaller point is readily attached, behind which are two mould-boards, which can be expanded so as to turn out a furrow if used for making a drill in which to plant potatoes, or as a ridging plough to throw the earth on either side if used for the purpose of earthing up the growing plants.

L. D. SAWYER & Co., Hamilton, Ontario, Canada.

Mowing and Reaping Machines.

Report.—Commended for excellent material and ingenious arrangement. Clutch gear replaced by eccentric ratchet on driving wheels without springs. Inside driving wheel one inch greater diameter than outside wheel, consequently covers more ground at each revolution, and tends to counteract side

draft. Knife-bar suspended on drag-bar, which can be screwed up to frame, so as to secure the position of the bar always at a right angle. As a reaper the platform can be hinged back behind the main frame, so as to facilitate its passage through narrow gateways.

JOSEPH E. STONG, Ontario, Canada.

Swinging Farm Gate.

Report.—Commended for an ordinary gate, not too heavy, sustained between two vertical standards at its rear end, and by two inclined levers, which proceed from the bottom of the rear end to the top rail of the gate, near the middle, and are there confined by sound bolts, which allow them to swing vertically and radially as the gate rises. The gate is raised by an attachment to the short end of a long lever, with its fulcrum on one of the upright standards, the long arm of which stands out at right angles to the rear of the gate far enough to be reached by one on horseback or in a carriage. The gate being so raised is carried up and over the segment of a circle the length of the gate, and set out and down its own length. A pull on the same lever, or on a similar one on the other side of the gate, throws it again over and back to place, and restores it to a closed position, where it is automatically locked.

ACTON PLOUGHING CO., Ontario, Canada.

General Purpose Plough.

Report.—Commended as a strong, serviceable implement, with adjustable coulter box, which slides on beam; for solid wrought-iron socket, giving great strength. The sole is cast, and can be easily removed; mould-board and land side steel.

THOMAS YEANDLE, Stratford, Ontario, Canada.

Single Plough.

Report.—Commended for useful general purpose plough, well made, saving of undue friction by peculiar construction of under side of share and mould-board; for steel sole with small ground surface; for peculiar form of land side, allowing of considerable wear; adjustable steel mould-board of good form.

C. DUPERROW, Stratford, Ontario, Canada.

Iron Diagonal Harrow.

Report.—Commended for construction of teeth, which, being diagonal, can be changed; also for the form of collar, which is diagonal, and fits into similar openings on the lower bars of the frame, thus securing a tight joint and making the connexion independent of the screw and nut.

MUNROE & AGAR, Seaforth, Ontario, Canada.

Combined Iron and Wood Plough.

Report.—Commended for the mode of attaching the wooden handles, which are riveted into strong wrought-iron standards well stayed, and for general excellence of construction.

G. WILKINSON, Aurora, Ontario, Canada.

Double Plough.

Report.—Commended as a well-made implement, likely to be useful in light lands; for the method of adjusting the width of furrows, and for the use of a friction-wheel behind the mould-board in place of the ordinary sole and land side; for reversible standard for this hind wheel.

PETER GRANT, Clinton, Ontario, Canada.

Excelsior Hay Fork and Conveyer.

Report.—Commended as a simple, cheap, and efficient labour saver. The conveyer is particularly commendable. The friction rollers travel on an ordinary scantling three by four, which is supported at intervals by simple hooks. The fork is composed of three tines, the centre of which has a double harpoon. The barbs rest on shoulder of standard, which gives great strength. The conveyer frame has friction rollers above and under the rail.

JOHN WATSON, Ayr, Ontario, Canada.

General Collection of Agricultural Implements.

Report.—Commended for the large and useful collection of machinery, and for general good workmanship, especially directing attention to a two-rowed ridge drill for root crops, and a heavy wooden roller adjustable to hill-sides and inequalities of surface; also for metal mills, pulping and slicing machines, and for a pneumatic chaff cutter.

THOMAS WILSON, Richmond Hill, Ontario, Canada.

Fanning Mill.

Report.—This mill is constructed on the most approved models, and in a thorough manner. It has an unusually large number of screens so arranged as to assort every kind of grain and seed, and chutes to carry off the tailings. The shaker is made in two parts, which move in unequal motions, thus causing a more thorough separation of the contents. The machine was arranged to be run by manual or other power.

DAVID MAXWELL, Paris, Ontario, Canada.

Power Chaff Cutter.

Report.—Commended for power chaff cutter, with patent gearing by which reverse motion, change of cut, and stop motion are obtained without the use of a clutch or change of wheels. This is effected by an ingenious cluster of wheels on lever axle; when the lever is in the stop hole, pulling the handle towards the feeder and from the machine reverses the rollers, a fairly safe arrangement.

A. ANDERSON, London, Ontario, Canada.

Hand Box Chaff Cutters.

Report.—Commended for a diagonal blade with a ragged-edge knife, which is also adapted for a hay cutter and bread knife.

HAGGERT BROTHERS, Brampton, Ontario, Canada.

Thrashing Machine and Horse Gear.

Report.—Commended for efficiency, strength of construction, and good workmanship, for the protection against accidents by the shielding of all shaftings; for the strong attachment of the poles to the horse gear; the drum is driven by gearing, and all the other speeds are multiplied from a comparatively slow motion, which is more economical than the ordinary plan of reducing speed from the drum shaft; for simple arrangement by which straw can be delivered by elevator at any required angle.

JOHN ABELL, Woodbridge, Ontario, Canada.

Portable Engine and Thrashing Machine.

Report.—Commended for economical arrangement of water heater and general excellence of engine, especially good lagging, and complete boiler fittings; for simplicity, strength, and efficiency of the thrashing machine; for adjustable straw elevator, and general compactness of parts.

JACOB BRICKER, Waterloo, Canada.

Little Champion Thrashing Machine.

Report.—Commended as a well-made machine, either driven by gearing or strap, the gearing well protected by a cover; for using Guiser's self-regulating air openings for fan, which tend to insure regularity of blast; for efficient straw-shakers worked by double reacting crank, insuring due progression and agitation of the straw, and complete separation of loose grain, which falls through openings in the shakers. The winnowing shoe, actuated by cams on either end of a revolving cross screen, gives a steady, uniform motion; straw carrier, hooked on to end of machine when working in a straight line, can be detached and set upon trestles, if required, to deliver at an angle; carriage on two wheels with blocks at either end; price reasonable.

GROUP XXIV.—MEDICINE, SURGERY, PROTHESIS.

R. BLACKWOOD & Co., Montreal, Canada.

Mineral Waters.

Report.—Commended for the excellent quality of their Belfast ginger ale and lemonade.

CHARLES WILSON, Toronto, Canada.

Mineral Waters.

Report.—Commended for the excellence of his soda and potash waters.

GROUP XXV.—INSTRUMENTS OF PRECISION, RESEARCH, EXPERIMENT AND ILLUSTRATION, INCLUDING TELEGRAPHY AND MUSIC.

WEBER & Co., Kingston, Ontario, Canada.

Square Piano.

Report.—Commended for tone, touch, and workmanship.

DOMINION ORGAN CO., Bowmanville, Ontario, Canada.

Reed Organs.

Report.—Commended because they have produced in their instruments a pure and satisfying tone by their method of voicing, and have a simple and efficient stop-action, with satisfying musical combinations, an elastic touch, and good general workmanship.

HEARN & HARRISON, Montreal, Canada.

Surveying Instruments.

Report.—The exhibit of mathematical and surveying instruments of their own construction is very creditable to this firm.

GROUP XXVI.—ARCHITECTURE AND ENGINEERING.

H. R. IVIS & Co., Montreal, Canada.

Mediæval Wrought-iron Gates.

Report.—Commended for excellence of workmanship and beauty of design.

S. R. FOSTER, St. John, New Brunswick.

Automatic Fire-proof Shutters.

Report.—Commended for the protection afforded against fire externally, and for the rapidity with which all the shutters in the building may be closed.

Canada.

Group XXVII.—Plastic and Graphic Art.

Group XXVII.

A. N. Greig, Montreal, Canada.

Imitations of Wood and Marble.

Report.—Commended for the merit of his grained imitations of woods and marbles, some of which are formed into panels by margins ornamented with decorative designs in colours, producing a pleasing effect.

Hovenden & Meldrum, Toronto, Ontario, Canada.

Painting on Glass.

Report.—Commended for merit of the specimens of sign painting on glass, which are of good and effective designs for the purpose and well executed, producing an agreeable decorative effect.

William J. Booth, Toronto, Ontario, Canada.

Sign Painting on Glass.

Report.—Commended for artistic execution, good design; very agreeable in general effect.

J. C. Spence, Montreal, Canada.

Window of Stained Glass.

Report.—Commended for fair elaboration of details, translucence, general effectiveness, and artistic execution.

A. Walker, Halifax, Nova Scotia.

Gilding on Glass.

Report.—The specimen of gold decoration on glass, the designs of which are taken from the Loggie of the Vatican, is extremely well executed, and is suggestive of the introduction of this mode of decoration where suitable, which would be durable and easily kept clean.

W. Notman, Montreal, Canada.

Photographs.

Report.—Commended for artistic excellence of photographs from life and hunting groups.

D. Fowler, Canada.

Painting in Water-Colour.

Report.—Commended for artistic excellence.

Group XXVIII.

Group XXVIII.—Education and Science.

Hunter, Rose, & Co., Toronto, Ontario, Canada.

Publications.

Report.—Commended for the good printing of important and useful publications.

Lovel Printing and Publishing Co., Montreal, Quebec, Canada.

School and other Books.

Report.—Educational books of general excellence and utility.

NELSON LOVERIN, M.D., Montreal, Canada.

Loverin's Historical Centograph.

Report.—It is a useful device for teaching history to pupils of intermediate schools, based upon what has been known as the Bern's method of representation.

YOUNG MEN'S CHRISTIAN ASSOCIATION OF AMERICA AND CANADA.

Chart showing the Location, Branches, and Agencies, and Photographs.

Report.—The useful labors of the association are widely known.

DEPARTMENT OF PUBLIC INSTRUCTION for the Province of Ontario, Canada.

Maps, Apparatus, Charts, School-House Models, Pupils' Work, Library, Text, and other Books.

Report.—Commended for a quite complete and admirably-arranged exhibit, illustrating the Ontario system of education, and its excellent results; also for the efficiency of an administration which has gained for the Ontario Department a most honourable distinction among Government educational agencies.

S. P. MAY, M.D., Toronto, Ontario, Canada.

Collection of Stuffed Animals for teaching Zoology.

Report.—A good typical collection, well prepared, and of reasonable price.

CANADA SCHOOL APPARATUS MANUFACTURING CO., Toronto, Ontario, Canada.

Laboratory and other Apparatus.

Report.—Good and cheap apparatus for illustrating various branches of science.

JAMES BROWNE, Toronto, Ontario, Canada.

Map Stand and Elevator.

Report.—Commended for novelty, utility, and fitness for the object intended, —that being the exhibiting of large maps or illustrated diagrams, and similar school appliances.

GROUP XXIX.—HORTICULTURE.

PROFESSOR JOHN MACOUN, Belleville, Ontario, Canada.

Herbarium.

Report.—Native Canadian flora systematically arranged, complete, and in excellent condition for botanical reference.

V. CASCI, St. Vincent, Toronto, Canada.

Fruit Models.

Report.—Fruit models artistically produced and coloured.

GROUP XXX.—HORSES, MULES, AND ASSES.

J. & D. BOAG, Ravenshoe, Ontario, Canada.

Horses and Mares.

Report.—"Jane." Clydesdale mare, seven years old. A standard mare in her class in every point.

"Fancy." Draught mare, one-year-old filly. A very grand filly, of fine proportions, and of great merit.

"Fancy." Clydesdale filly, one year old. A very superior filly, of wonderful promise.

"Faun." Agricultural mare, seven years old. A standard mare, specially adapted to the purpose.

"Jane," with foal at foot and filly foal. Clydesdale brood mare, seven years old. A model brood mare in every respect, with a very superior filly foal of very great promise.

"Dundonald." Clydesdale stallion, eight years old. He is a strong, very useful horse; very muscular, with strong back and loin, but only of very moderate action.

JEFFREY BROTHERS, Whitby, Ontario, Canada.

Mares.

Report.—"Coldstream Lass." Clydesdale mare, three years old; will make a good draught mare. A standard mare of her class in every point.

GEORGE CURRIE, Ingersoll, Ontario, Canada.

Mare and Matched Team.

Report.—"Faun." Draught mare, six years old. A very good, useful mare.

"Dexter" and "Faun." Matched team of agricultural horses. A very superior team for the purpose.

JOHN GLENN, Carlow, Ontario, Canada.

Mares.

Report.—"Fanny." Agricultural filly, one year old. A superior filly, of great promise.

"Jennie." Agricultural filly, two years old; will make a good draught mare. A very superior filly, of great promise.

"Jessie." Draught mare, seven years old. A superior mare, of very great quality.

JOHN SMITH, Raglan, Ontario, Canada.

Mares.

Report.—"Dash." Clydesdale filly, two years old; will make a good draught mare. A filly good in all points.

GEORGE DODGE, Columbus, Ontario, Canada.

Mares.

Report.—"Queen of the Dominion." Agricultural filly, two years old; will make a good draught mare. Good in all points.

"Empress." Clydesdale mare, four years old. A mare good in all points.

JOHN GAILBRAITH, Kirby, Ontario, Canada.

Mare and Horse.

Report.—"Mollie." Roadster mare, age six years; height, fifteen hands three inches; weight, one thousand and fifty-four pounds; colour bay. Of good form, strong legs, with good joints and feet, and of excellent style and action, fair for a roadster mare.

"Jollie." Age, five years; height, fifteen hands three inches; weight, one thousand pounds; bay, with white foot and star. Well bred, fine form and action for roadster gelding.

WILLIAM GERRIE, Dundas, Ontario, Canada.

Mares.

Report.—"Polly" and "Fan." Match team of heavy draught mares; age, four years and six years. A superior team of not only heavy draught, but also as brood mares.

"Faun." Agricultural mare, six years old. A standard mare, specially adapted to the purpose.

HENRY SARTER, Ponsonby, Ontario, Canada.

Mares.

Report.—"Fanny." Agricultural filly, one year old; will make a good draught mare. Well adapted to the purpose; of excellent promise.

W. HURDMAN, Ottawa, Ontario, Canada.

Draught Mare and Stallion.

Report.—"Black Bess." Draught mare, nine years old. A very fine mare in every essential requisite.

"Farmer's Fancy." Draught stallion, two years old. A fair horse, of special quality.

T. & J. LITTLE, Sandhill, Ontario, Canada.

Horse.

Report.—"Young Wonder." English draught horse, five years old. A finely-finished horse, good in all his points, and suitable for the purpose.

C. J. DOUGLASS, Oak Ridge, Ontario, Canada.

Horse.

Report.—"Marquis." Clydesdale stallion, six years old. He is a good, useful horse, strong in most points essential to a draught horse, of good appearance, only of moderate action, overloaded with fat.

W. J. DOUGLASS, Wellington Square, Ontario, Canada.

Horse.

Report.—"Sharp Catcher." Bay horse, six years old. By "Luther" (he by "Lexington"), dam "Maritana". He is a large strong stallion, and from his from is bound to get good strong stock for all useful purposes, from the saddle to the road.

J. W. WHITE, Milton, Ontario, Canada.

Horse.

Report.—"Terror." Brown horse, fifteen hands two and a half inches high; ten years old; dam imported "Maritana." He was foaled in Canada; but we have no record of his running, which was chiefly done there. He has been in the stud for some time. He is an evenly well-made muscular horse, and should succeed as a sire.

WM. CLARKE, Greenwood, Ontario, Canada.

Horse.

Report.—"Warmanbio." Thoroughbred. Imported bay, aged fifteen years; height, fifteen hands three inches; good body, strong neck and head, legs fair, good eyes, broad back. Good stock horse, by "Mountain Deer."

Canada.

Group XXX.

WM. NEWHOUSE, Brampton, Ontario, Canada.

Horse.

Report.—"McKenzie." Roadster stallion. Age, three years; height, fifteen hands three inches; weight, one thousand one hundred pounds; colour, dark chesnut with white stocking; breeding excellent; "sire Royal George"; form very superior, with excellent legs, joints, and feet, with superior muscle and style, and of good action for a roadster stallion.

HUGH COOPER, Canada.

Horse.

Report.—"Blucher." Roadster stallion. Having attained the standard of a roadster stallion, finely developed, well proportioned, and perfect in form, and gives indications of speed for a two-year-old.

JAMES MCDONOUGH, Carlow, Ontario, Canada.

Mare.

Report.—"Fanny." Agricultural mare, seven years old. A very superior mare of her class in every point.

WM. LONG, Lansing, Ontario, Canada.

Horses.

Report.—"Lord Zettona." Coach stallion. Age, four years; height, fifteen hands three inches; weight, good; colour, dark bay; excellent breeding; superior form, legs, joints, and feet, with very excellent muscle. Style superior, and action superb for a coach stallion.

"Royal Tom." English draught horse, four years old. A good useful horse, good in all points requisite for a heavy draught horse.

WM. HARRIS, Mount Elgin, Ontario, Canada.

Horses.

Report.—"Pete" and "Charley." Carriage horses. Age, seven and eight years; height, sixteen hands; one thousand and fifty-six and one thousand one hundred and twenty-six pounds; colour, bay. Breeding, English coach and driver; very well formed; strong make and fair roadsters, well matched, and kind clever drivers for family carriage horses.

HALLIBURTON KENNEDY, Birr, Ontario, Canada.

Mare and Horse.

Report.—"Maggie" and "Billy." Age, five and six years; height, sixteen hands; weight, eleven hundred and fifty-five pounds; colour, black; a fine well-matched mare and horse carriage team, of superior form, style, and action.

WILLIAM BOYD, Toronto, Ontario, Canada.

Horses.

Report.—"Tom" and "Bill." Heavy draught matched team, each five years old. A superior team, specially adapted to the purpose.

JOSEPH J. FISHER, Ben Miller, Ontario, Canada.

Horse.

Report.—"Pat Malloy." Agricultural stallion, six years old. A very superior horse, of fine from and action, and worthy of much credit.

J. P. Fisher, Ben Miller, Ontario, Canada.

Horse.

Report.—"Peacock." Stallion. Age six years; height sixteen hands two inches; weight, one thousand four hundred pounds; colour, bay; shows fine breeding, is of excellent form, make, and style, with good action and all essential points of a first-class coach horse.

Andrew Somerville, Huntington, Ontario, Canada.

Horse.

Report.—"British Splendour." Stallion. Age, twelve years; height, fifteen hands two inches; weight, one thousand three hundred and ninety-two pounds; colour, dark bay; of fine form and carriage. Limbs a trifle light, but action very good, and on the whole a very good coach stallion.

Alexander Burgess, Weston, Ontario, Canada.

Horse.

Report.—"Honest Sandy." Clydesdale stallion, four years old. A good useful horse, of fine form, and action above the average class of horses.

D. R. Hick, Mitchell, Ontario, Canada.

Horse.

Report.—"Lord Logan." Agricultural stallion, two years old. A fine young animal, well adapted for the purpose; of fine style and action.

David Fisher, Colburn, Ontario, Canada.

Horse.

Report.—"Beauty of the Dominion." Stallion; age, two years; height, sixteen hands; weight, one thousand two hundred and fifty pounds; colour, bright bay; breeding very superior; by "Peacock," "Morgan" dam; well developed; of superior form and style, with excellent action for a coach stallion.

Ezra Holt, Orino, Ontario, Canada.

Horse.

Report.—"Performer." Stallion; age, thirteen years; height, sixteen hands two inches; weight, one thousand four hundred and forty pounds; colour, dark bay; well bred, of fine carriage and form, of excellent style and fair action; a fine representation of Cleveland Bay stallion.

C. E. Mason, Brucefield, Ontario, Canada.

Horse.

Report.—"Glenelg." Clydesdale stallion, four years old. A superior horse, of great merit, good in all respects.

Wm. McKenzie, Columbus, Ontario, Canada.

Horse.

Report.—"Luck's All." Stallion; age, four years; height, sixteen hands one inch; weight, one thousand three hundred and forty-seven pounds; colour, bay; of excellent breeding, superior form, foot, and muscle, and very elegant style and action for a coach stallion.

J. T. Jenkins, Charlottetown, Prince Edward's Island.

Horse.

Report.—"Royal Harry." Age, five years; height, sixteen and a half hands; weight, one thousand three hundred pounds; colour, brown; breeding good, with excellent form and fine style. His action is good for a roadster stallion.

Group XXXI.—Cattle.

George Hood, Guelph, Ontario, Canada.

Hereford and Galloway Cattle.

Report.—Hereford bull "Hero." Commended for his fine character, form, and quality. He is, altogether, a very superior animal, and in all respects ranks as a first-class Hereford.

Hereford bull "Robin Hood," Hereford bull "Victor 3d.," Hereford cow "Victoria." Commended for their good character, form, and quality. We consider them superior Herefords.

One black Galloway cow "Lady Isabel," one black Galloway bull "Roger;" one herd of Galloways, one bull, four cows. For high excellence in form, quality, and useful characteristics they are entitled to rank as, in all respects, first-class specimens of the Galloway breed.

One black Galloway cow "Lily Dale." In form, quality, and useful characteristics she is entitled to rank as a superior specimen of the Galloway breed.

J. & R. Hunter, Alma, Ontario, Canada.

Short-horn Cattle.

Report.—Heifer "Maid of Honour 2d," heifer "Belle of Sunnyside," bull "Ranger." In form, quality, and useful characteristics they are entitled to rank as superior specimens of the short-horn breed.

Cow "Rose Blossom," bull "Lord Aberdeen," herd of cattle. In high excellence of form, quality, and useful characteristics they are entitled to rank as, in all respects, first-class specimens of the short-horn breed.

William Miller, Jr., Atha, Ontario, Canada.

Short-horn Cattle.

Report.—Heifer "Young Arabella," heifer "Necklace 7th." For high excellence, quality, and useful characteristics they are entitled in all respects to rank as first-class specimens of the short-horn breed.

Heifer "2d Rose of Oxford." In form, quality, and useful characteristics she is entitled to rank as a superior specimen of the short-horn breed.

Satchell Brothers, Ottawa, Ontario, Canada.

Short-horn Cattle.

Report.—Heifer. She is an animal of fine character, extremely well and evenly fed, of superior quality of flesh, great substance, and very fine in the bone. She is, altogether, a most superior animal.

Grade ox "Lord Dufferin." He is an animal of great scale, combined with excellent quality of flesh and a minimum of offal, and altogether a very superior animal.

George Rudd, Guelph, Ontario, Canada.

Devon Bulls.

Report.—Bull "Hartland." In form, quality, and useful characteristics he is entitled to rank as a superior specimen of the Devon breed.

Bull "Duke of Wellington." In form, quality, and useful characteristics he is entitled to rank as an excellent specimen of the Devon breed.

James Russell, Richmond Hill, Ontario, Canada.

Short-horn Cattle.

Report.—Herd of cattle, heifer "3d Duchess of Springwood," bull "High Sheriff," cow "Isabella." In excellence of form, quality, and useful characteristics they are entitled to rank as superior specimens of the short-horn breed.

Bull "High Sheriff 2d." For high excellence in form, quality, and useful characteristics he is entitled to rank in all respects as a first-class specimen of the short-horn breed.

WILLIAM RODDEN, Plantagenet, Ontario, Canada.

Ayrshire and Jersey Cattle.

Report.—Ayrshire bull "Carrick Lad," four and a half years old. A bull of fine style, and possessing many excellent qualities.

Ayrshire bull—calf—"General Montgomery," nine months old. A very fine calf, of high promise.

Ayrshire heifer "Lily," two years old. A fine heifer, of excellent promise.

Jersey cow "Pride of Home." Two years old. This cow has good udder and teats, a mellow hide, yellow in colour, and a good escutcheon.

W. B. TELFER, Ponsonby, Ontario, Canada.

Short-horn Cattle.

Report.—Heifer "Maid of Kent 2d," heifer "Rosedale 2d," bull "3d Duke of Kent." In form, quality, and useful characteristics they are entitled to rank as superior specimens of the short-horn breed.

Heifer "Duchess of Kent." For high excellence, quality, and useful characteristics she is entitled in all respects to rank as a first-class specimen of the shorthorn breed.

THOMAS BOAK, Hornby, Ontario, Canada.

Short-horn Bull.

Report.—"Duke of Cumberland." For high excellence in form, quality, and useful characteristics he is entitled to rank as, in all respects, a first-class specimen of the short-horn breed.

DOMINION OF CANADA.

Herd of Short-horn Cattle.

Report.—One bull and four cows. The animals composing this herd, in high excellence of form, quality, and useful characteristics, are entitled to be ranked as first-class specimens of the short-horn breed.

GEORGE THOMSON, Bright, Ontario, Canada.

Ayrshire Cow.

Report.—"Mermaid," four years old. A very superior cow.

GROUP XXXII.—SHEEP.

P. & J. BROOKS, Whalen, Ontario, Canada.

Leicester Sheep.

Report.—Four ewes; one ram; flock, three shearling ewes. Commended as first-class specimens of the breed.

Flock, three shearling ewes; flock, three shearling ewes. Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as very superior specimens of the breed to which they belong.

DOMINION OF CANADA, Province of Ontario.

Ram and six Ewes.

Report.—Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as very superior specimens of the breed to which they belong.

JAMES HEALY, Adelaide, Ontario, Canada.

Lincoln Sheep.

Report.—Ram "Victory." Commended as an excellent specimen of the breed.

Flock, three shearling ewes. Commended as first-class specimens of the breed.

Canada.

Group XXXII.

WILLIAM HODGSON & SON, Myrtle, Ontario, Canada.

Cotswold Sheep.

Report.—One ram; four ewes; three breeding ewes; shearling ram "1st Gray-faced Prince." Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as very superior specimens of the breed to which they belong.

Three shearling ewes. Commended as excellent specimens of their breed.

Three breeding ewes; one ram, "2d Gray-faced Prince." Commended as first-class specimens of their breed.

SAMUEL LANGFORD, Granton, Ontario, Canada.

Lincoln Sheep.

Report.—Lincolnshire ram; flock, one ram and four ewes; three breeding ewes; Lincoln ram; pen of three breeding ewes; Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as being very superior specimens of the breed to which they belong.

Flock shearlings, three ewes. Commended as first-class specimens of their breed.

ROBERT MARSH, Richmond Hill, Ontario, Canada.

Southdown Sheep.

Report.—Three shearling ewes; three breeding ewes; ram, three years old; flock, one ram and four ewes; three ewe lambs. Commended as first-class specimens of the breed to which they belong.

Three shearling ewes; ram, four years old; ram lamb. Commended as excellent specimens of the breed to which they belong.

GROUP XXXIII.—SWINE.

Group XXXIII

A. FRANK & SONS, Cheltenham, Ontario, Canada.

Suffolk Swine.

Report.—Boar and two sows, "Tom Bush," "Maggie," and "White Rose." Commended for high excellence in quality, symmetry, large constitutional development, and as very superior specimens of the breed to which they belong.

HENRY MILTON, Ridgetown, Ontario, Canada.

Chester White Sows.

Report.—Boar "Champion" and sow "Slick." Commended as first-class specimens of the breed to which they belong.

Sow "Excelsior." Commended for high excellence in quality, symmetry, large constitutional development, and as a very superior specimen of the breed to which she belongs.

GEORGE NEWLOVE, Mackville, Ontario, Canada.

Berkshire Swine.

Report.—"Lady Jane." Commended as a first-class specimen of her breed.

Boar "Billy Crawford." Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as a very superior specimen of the breed to which he belongs.

WRIGHT & BUTTERFIELD, Sandwich, Ontario, Canada.

Suffolk and Essex Swine.

Report.—Suffolk sows, "Faith," "Hope," "Charity," and "Suffolk Queen;" Essex sows, "Negro's Best," "Negress 2d," "Negress 3d," "Princess," and

"Queen of Essex;" Suffolk boars, "Longback" and "Suffolk King;" Essex boars, "Negro," "Negro 1st," "Negro 2d," and "Negro 3d;" Essex sow and four pigs; Essex sow and nine pigs. Commended for high excellence in quality, uniformity, symmetry, great constitutional development, and as very superior specimens of the breeds to which they belong.

Essex boar "Negro 4th." Commended as a first-class specimen of his breed.

Group XXXIV.—Dogs.

L. H. Smith, Strathroy, Ontario, Canada.

Imported English Setter Dogs "Leicester" and "Paris," over two years; Imported English Setter Dog "Llewellin," over one and under two years.

Group XXXV.—Poultry.

Daniel Allen, Galt, Ontario, Canada.

Variety of Fowls.

Report.—Four pairs of black-red game fowls; two pairs of black-red game chicks; two pairs of brown-red game fowls; one pair of brown-red game chicks; two pairs of yellow duck-wing fowls; one pair of yellow duck-wing chicks; one pair of Pyle fowls; one pair of Pyle chicks; one pair of golden duck-wing fowls; two pairs of black-red Bantam fowls; two pairs of black-red Bantam chicks; one pair of silver duck-wing fowls; one pair of golden duck-wing fowls; one pair of golden duck-wing chicks; one pair of red Pyle chicks; one pair of black African fowls; one pair of black African chicks; one pair of white-crested white Polish fowls; one pair of golden-crested white Polish fowls; one pair of bearded silver Polish fowls; four pairs of black-red game fowls; two pairs of black-red game chicks; one pair of Aylesbury ducks; and one pair of Rouen ducks. Commended as superior specimens of their breed.

John Bogue, London, Ontario, Canada.

Variety of Fowls.

Report.—Two pairs of white-crested Polish fowls; one pair of white Dorking fowls; one pair of silver-gray Dorking fowls; one pair of Houdan fowls; one pair of Aylesbury ducks; and one pair of Aylesbury ducklings. Commended as superior specimens of their breed.

James Beswick, Toronto, Ontario, Canada.

Game Fowls.

Report.—One pair of black-red game fowls; one pair of brown-red game fowls. For high excellence in quality these fowls are entitled to rank as superior specimens of their breed.

W. M. Campbell, Brooklyn, Ontario, Canada

Variety of Fowls.

Report.—One pair of golden Sebright Bantams; one pair of silver Sebright Bantam chicks; one pair of rose-comb white Bantam fowls. For high excellence in quality these fowls are entitled to rank as superior specimens of their breed.

One pair of black Hamburgs. Commended as superior specimens of their breed.

One pair of black-breasted red game Bantams; one pair of brown-breasted red game Bantam chicks; one pair of golden duck-wing fowls; one pair of red Pyle chicks; and one pair of brown Leghorn fowls. Commended as excellent specimens of their breed

H. Cooper, Hamilton, Ontario, Canada.

Variety of Fowls.

Report.—One pair of black barb pigeons. Commended as superior specimens of their breed.

One pair of black fan-tail pigeons, and one pair of silver duck-wing Bantam fowls. Commended as excellent specimens of their breeds.

One pair of black Jacobin pigeons. Commended as meritorious specimens of their breed.

W. H. Doel, Toronto, Ontario, Canada.

Variety of Fowls.

Report.—One pair of white China. Commended as superior specimens of their breed.

Two pairs of dark Brahma chicks. Commended as excellent specimens of their breed.

One pair of black-breasted red game Bantam fowls; two pairs of black-breasted red game chicks. For excellence in quality these fowls are entitled to rank as meritorious specimens of their breed.

Wm. Forbes, Grimsby, Ontario, Canada.

Fowls.

Report.—One coop of white Cochin chicks. Commended as superior specimens of their breed.

W. G. Hewson, Oakville, Ontario, Canada.

Fowls.

Report.—One pair of white Leghorn chicks. Commended as superior specimens of their breed.

Platt Hinman, Grafton, Ontario, Canada.

Ducks.

Report.—One pair of coloured Muscovy ducks. Commended as superior specimens of their breed.

Duncan Kay, Galt, Ontario, Canada.

Variety of Fowls.

Report.—One pair of golden pencilled Hamburg fowls; one pair of golden pencilled Hamburg chicks; two pairs of silver pencilled Hamburg chicks; two pairs of black Hamburg chicks; one pair of white-faced black Spanish fowls; and two pairs of white-faced black Spanish chicks. Commended as superior specimens of their breeds.

One pair of silver duck-wing Bantams. Commended as excellent specimens of their breed.

Perley & McCummings, Paris, Ontario, Canada.

Game Chicks.

Report.—One pair of black-breasted red game chicks. For high excellence in quality these fowls are entitled to rank as superior specimens of their breed.

Richard McMillan, Galt, Ontario, Canada.

Variety of Fowls.

Report.—One pair of silver-spangled Hamburg fowls; one pair of golden-spangled Hamburg fowls; one pair of silver-pencilled Hamburg fowls; one pair of silver-pencilled Hamburg chicks; two pairs of golden-pencilled Hamburg fowls; one pair of golden pencilled Hamburg chicks; one pair of black Hamburg fowls; two pairs of black Hamburg chicks; one pair of black African

fowls; one pair of white-faced black Spanish fowls; and two pairs of white-faced black Spanish chicks. Commended as superior specimens of their breeds.

One pair of Pyle Bantam fowls; one pair of white Dorking fowls. Commended as excellent specimens of their breeds.

WM. MCNEIL, London, Ontario, Canada.

Polish Chicks.

Report.—One pair of silver-bearded Polish chicks; and one pair of golden-bearded Polish chicks. Commended as superior specimens of their breed.

THOMAS PELLOW, London, Ontario, Canada.

Variety of Fowls.

Report.—One pair of white-faced black Spanish chicks; and one pair of Houdan fowls. Commended as excellent specimens of their breeds.

One pair of coloured Dorking fowls. Commended as superior specimens of their breed.

J. PLUMMER, London, Ontario, Canada.

Polish Chicks.

Report.—Two pairs of white-crested black Polish chicks. Commended as superior specimens of their breed.

W. M. SMITH, Fairfield Plains, Ontario, Canada.

Variety of Fowls.

Report.—One pair of La Flèche fowls; one pair of Aylesbury ducklings; one pair of Cayuga ducks; one pair of Cayuga ducklings; one pair of white Muscovy ducks; one pair of coloured Muscovy ducks; two pairs of coloured Muscovy ducklings; and one pair of white China geese. Commended as superior specimens of their breeds.

One pair of Crevecœur chicks; one pair of La Flèche chicks; one pair of La Flèche chicks; one pair of white Leghorn fowls; one pair of black Leghorn fowls; and one pair of black Leghorn chicks. Commended as excellent specimens of their breeds.

One pair of Crevecœur fowls. Commended as meritorious specimens of their breed.

A. TERRILL, Wooler, Ontario, Canada.

Ducks and Geese.

Report.—One pair of Rouen ducks; one pair of brown China geese; and one pair of Bremen geese. Commended as superior specimens of their breeds.

H. M. THOMAS, Brooklyn, Ontario, Canada.

Variety of Fowls.

Report.—One pair of black-breasted red game fowls; one pair of yellow duck-wing fowls; one pair of silver duck-wing fowls. For high excellence in quality these fowls are entitled to rank as superior specimens of their breed.

One pair of Houdan fowls; one pair of white Leghorn fowls; one pair of partridge Cochin fowls; one pair of buff Cochin fowls; one coop of light Brahma fowls; one coop of light Brahma chickens; one coop of white-crested Polish fowls; two coops of golden bearded Polish fowls; and two coops of silver-bearded Polish fowls. Commended as superior specimens of their breeds.

One pair of dark Brahma fowls. Commended as excellent specimens of their breed.

One pair of black Cochin fowls. Commended as meritorious specimens of their breed.

Canada.

Group XXXV

H. & T. Waddell, Hamilton, Ontario, Canada.

Hamburgs.

Report.—One pair of golden-spangled fowls. Commended as superior specimens of their breed.

John Weld, London, Ontario, Canada.

Dorking Chicks.

Report.—Two pairs of silver-gray Dorking chicks. Commended as superior specimens of their breed.

Group XXXVI.

Group XXXVI.—Pomology.

J. W. Newman, Lachine, Canada.

Seedling Apples.

Report.—Commended for the reason that among sixty-one kinds of seedling apples so many should give promise of great excellence.

Donald Smith, Ontario, Canada.

Apples.

Report.—Two kinds of apples, "Ribston Pippin" and "King of Tompkins County," were of unusual size and of excellence in other respects.

James Dougall, Windsor, Ontario, Canada.

Collection of Apples.

Report.—Commended for a large and fine collection of apples of well-known and valuable varieties; and also for a display of thirty-one varieties from trees recently imported by him from France and possessing marked peculiarities, among which is "Api Noir" (Black Lady-apple), an exceedingly rare variety in this country.

Charles Arnold, Paris, Ontario, Canada.

Collection of Apples.

Report.—Commended for a large collection of correctly-named and well-grown apples, especially as a recognition of the value of his labours as a hybridizer, as illustrated by specimens exhibited of hybrid apples numbered 3, 4, and 5 in this collection.

Fruit Growers' Association of the Province of Ontario, Canada.

Additional Exhibit of Apples.

Report.—A very large and meritorious collection of apples, illustrating the capacities of the soil and climate for fruit growing, and indicating the progress of the people in pomology; a large proportion of the whole well grown and finely coloured.

Hugh Scott, Jr., London, Ontario, Canada.

Apples.

Report.—One variety he exhibits, called "Thompson's Jelly Russet," is of such superior excellence among russet apples as to merit special recognition.

James M. Stay, Masonville, Ontario, Canada.

London Pippin Apple.

Report.—This apple, always beautiful, was, in addition to its unusually large size, of delicious flavour.

FRUIT GROWERS' ASSOCIATION of the Province of Ontario, Canada.

Pears.

Report.—Sixty-seven varieties, many of which are well grown. The "Flemish Beauties" generally are choice, some of them being really superb, showing this variety to be especially adapted to the climate of Ontario. The "Bartletts" are also well grown, and large for that latitude.

PROVINCE OF NOVA SCOTIA.

Collection of Fruit.

Report.—A remarkably instructive exhibit, during the week ending October 19th, of the fruits of Nova Scotia. It embraced one hundred and ninety-one kinds, including seven of crabs, fifteen of grapes, and four of pears; the grapes ripened in the open air.

FRUIT GROWERS' SOCIETY of Ontario, Canada.

General Collection of early Berries and Fruits.

Report.—A large and varied collection, continued through several weeks —consisting of currants, gooseberries, cherries, raspberries, and apples.— deserving the highest commendation.

During the week ending September 21st, they made a very large exhibit of fruits,—embracing one hundred and twenty plates of apples, seven of plums, five of peaches, three of tomatoes, two of nuts,—exemplifying the excellent capacity of the soil and climate of the province to produce these fruits.

FRUIT GROWERS' ASSOCIATION of the Province of Ontario, Canada.

Grapes.

Report.—The extent of this collection, embracing sixty-five plates of native grapes, and nine of foreign grapes, is worthy of praise in consideration of the difficulty the fruit growers are obliged to encounter in this northern latitude. The specimens are generally well grown and ripened. We especially commend Mr. Charles Arnold's hybrid grapes.

J. MORGAN, JR., Quebec, Canada.

Collection of Grapes.

Report.—The fourteen kinds of grapes, some of them grown in the open air of this region, are of superior excellence.

CHARLES ARNOLD, Ontario, Canada.

Seedling Grapes.

Report.—One of these seedlings, the "Canada Superior," is so much like the "Clinton," yet superior in size and general qualities, as to be a good competitor with that well-known and popular grape.

MAYOR PAFFORD, Niagara, Ontario, Canada.

Exotic Grapes.

Report.—He exhibits black Hamburg grapes, grown in the open air, the bunch weighing sixteen and one-half ounces, and of excellent flavour, little inferior to the best specimens generally raised under glass.

THOMAS H. PARKER, Woodstock, Ontario, Canada.

Grapes under Glass.

Report.—His collection of hothouse grapes is of superior excellence in colour, flavour, and bunches of good average size. A bunch of "Victoria Hamburg" was of particularly beautiful form, and weighed one pound seven ounces.

Canada.

Group XXXVI.

WILLIAM YOUNG, Hamilton, Ontario, Canada.

Salem Grapes.

Report.—For that section of the country, they were of remarkable excellence in size of berry and bunch, and in flavour.

W. T. TAYLOR, Hamilton, Ontario, Canada.

Clinton Grapes.

Report.—The "Clinton" grapes, though grown so far north, were superior to the same variety as usually grown anywhere, in the size and beauty of the bunches and the flavour of the berries.

DOMINION OF CANADA (from the Province of Manitoba).

Esculents.

Report.—This highly instructive collection of field and garden vegetables was especially meritorious on account of the northern latitude where the products were grown. The potatoes were remarkably large and handsome.

Collective Exhibits.

COLLECTIVE EXHIBITS.

GOVERNMENT OF THE DOMINION OF CANADA.

Collective Exhibit.

Report.—Commended for a very superior display in all departments of the Exhibition, especially mineral, agricultural, forest industry, pomology, and education.

DEPARTMENT OF EDUCATION FOR THE PROVINCE OF ONTARIO, Canada.

Educational Apparatus and Appliances.

Report.—Commended for a very extensive and attractive collection illustrative of the growth and extent of the educational system of Ontario, including a great variety of apparatus, maps, charts, models of school-houses, photographs of school-buildings, and reports.

Cape of Good Hope.

CAPE OF GOOD HOPE.

Group I.

GROUP I.—MINERALS, MINING AND METALLURGY, INCLUDING THE MACHINERY.

E. I. DUNN, Cape Town, Cape of Good Hope.

Geological Map.

Report.—A small coloured geological map of South Africa.

SAMUEL STONESTREET, Kimberley Mines, Cape of Good Hope.

Diamonds.

Report.—An instructive collection of diamonds, some of them in the parent rock, from Griqualand.

H. C. R. BRIGHT, Cape of Good Hope.

Collection of Minerals.

Report.—Commended as an interesting collection of minerals, and copper, iron, and tin ores.

GROUP IV.—ANIMAL AND VEGETABLE PRODUCTS, AND THE MACHINERY FOR THEIR PREPARATION.

BARRY, ARNOLD, & Co., Cape Town, Cape of Good Hope.

Wheat Flour.

Report.—Colour fine, strength fair; makes good bread, but is especially adapted for biscuit and pastry.

E. CLEAR, Cape Town, Cape of Good Hope.

Wheat Flour,

Report.—Colour good, strength fair; makes good bread, but is especially adapted for biscuit and pastry.

BARRY, ARNOLD, & Co., Cape Town, Cape of Good Hope.

Wheat.

Report.—Commended for good appearance and weight.

N. MYBURGH, Meerlust, Cape Colony, Cape of Good Hope.

Wheat.

Report.—Commended for very fine appearance and great weight.

BENNINGFIELD & SON, Cape of Good Hope.

Native Ivory (Elephants' Tusks).

Report.—Commended for the large size and perfect soundness of the specimens exhibited.

S. ROSENBERG, Cape Town, Cape of Good Hope.

Brandy.

Report.—Very good, aromatic, and made of grape wine.

H. H. MARAIS, Robertson, Cape of Good Hope.

Brandy.

Report.—Very aromatic, and made from grape wine.

J. P. CLOETE, Cape of Good Hope.

Wines.

Report.—Very pure, of good taste and aroma.

DR. HAUF, Cape of Good Hope.

Wines and Brandy.

Report.—Muscatel wine very good; also a very fine sample of grape brandy, fine aroma and very clean spirit.

ANDERSON & MURISON, Cape of Good Hope.

Wines.

Report.—Of very good taste and aroma.

S. VAN REMEN, Cape of Good Hope.

Wines.

Report.—Red and white wines; very pure, of good taste and fine aroma.

Cape of Good Hope.

[Group IV.

E. K. GREENE, Cape of Good Hope.

Wines.

Report.—Very fine assortment of dry and sweet red wines; of good taste and aroma.

CLOETE BROTHERS, Cape of Good Hope.

Wines.

Report.—Very fine; of good taste and aroma.

Group V.

GROUP V.—FISH AND FISH PRODUCTS, APPARATUS OF FISHING, &C.

JOHN MERRIMAN, Cape Town, Cape of Good Hope.

Preserved Crayfish.

Report.—Commended for good preparation.

Group VI.

GROUP VI.—TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY.

MOSSOP & GARLAND, Cape Town, Cape of Good Hope.

Tan Barks from Eight Species.

Report.—Commended for the variety of the exhibit and excellence as shown by the leathers exhibited, which had been tanned with these varieties.

Group IX.

GROUP IX.—WOOL AND SILK FABRICS, WITH THE MACHINERY.

THE COLONY OF THE CAPE OF GOOD HOPE.

Wools.

Report.—A collection of samples, indiscriminately selected from bales for export, showing excellent merino and Angora wools.

Group XXIII.

GROUP XXIII.—AGRICULTURAL MACHINES, IMPLEMENTS OF AGRICULTURE, HORTICULTURE, AND GARDENING.

A. DOUGLASS, Hilton, Grahamstown, Cape of Good Hope.

Ostrich Incubating Machine.

Report.—Commended as an apparatus for hatching out ostrich eggs in a simple and efficient manner, and for keeping the young during the critical period of their early life.

The invention and use of this apparatus, and the treatment of the eggs and young of the ostrich by Mr. Douglass, have added a most important industry to the world, and in addition to averting the threatened extermination of this species, have greatly multiplied its numbers and increased the supply of its feathers for commercial purposes. These can now be taken year by year from the same (domesticated) bird, instead of involving its destruction for a single crop.

COLLECTIVE EXHIBIT. — Cape of Good Hope. — Collective Exhibit.

GOVERNMENT OF CAPE OF GOOD HOPE.

Collective Exhibit.

Report.—An interesting collection, arranged by one hundred exhibitors, and consisting of ores of copper and other minerals, coals, woods, seeds, articles of native dresses, printed matters, models of engineering works, photographs, and other illustrations of colonial scenery; also a large collection of wines and brandies, an ostrich incubator, precious stones, and preserved fruits.

CEYLON. — Ceylon.

GROUP I.—MINERALS, MINING AND METALLURGY, INCLUDING THE MACHINERY. — Group I.

DELMEGE, REID, & Co., Colombo, Ceylon.

Graphite, Raw and Prepared.

Report.—Commended for purity of the specimens of graphite exhibited.

COLLECTIVE EXHIBIT. — Collective Exhibit.

GOVERNMENT OF CEYLON.

Collective Exhibit.

Report.—A large display of the natural wealth of the island of Ceylon.

FIJI. — Fiji.

GROUP VIII.—COTTON, LINEN, AND OTHER FABRICS. — Group VIIIr.

RYDER BROTHERS, Mango Island, Fiji.

Sea-Island Cotton.

Report.—Commended for extraordinary length of staple, fineness and strength, and good handling.

GOLD COAST. — Gold Coast.

COLLECTIVE EXHIBIT. — Collective Exhibit.

GOVERNMENT OF THE GOLD COAST.

Collective Exhibit.

Report.—An interesting display of the natural resources of the Gold Coast.

INDIA. — India.

GROUP I.—MINERALS, MINING AND METALLURGY, INCLUDING THE MACHINERY. — Group I.

INDIA MUSEUM, London, England.

Collection of Minerals.

Report.—An interesting collection of the economic minerals of India.

India.
Group IV.

Group IV.—Animal and Vegetable Products, and the Machinery for their Preparation.

Murree Brewery Co., Punjab, India.

Ale.

Report.—Commended for the excellent quality of their strong ale and their XXX stout; remarkable for good condition, brightness, taste, and aroma.

India Museum, South Kensington, London, England.

Cereals.

Report.—Commended for the extent of its collection of seventy-five varieties of rice, in the husk, and cleansed; fifteen varieties of wheat, five varieties of oats, ten varieties of barley, seventy-five varieties of tea, twenty varieties of coffee, and a number of spices, and millet and grass seeds.

Group VIII.

Group VIII.—Cotton, Linen, and other Fabrics.

J. Forbes Watson, Director, India Museum, British India.

Vegetable Fibres.

Report.—Commended for the large and valuable collection of samples of cotton, flax, rheea, hemp, aloe, musa, and other vegetable fibres, embracing over forty species of great value, exhibited by the Museum under his care.

Group IX.

Group IX.—Wool and Silk Fabrics, with the Machinery.

India Museum, Kensington, London, England.

Silks and Mixed Fabrics.

Report.—A splendid display of Indian productions of silk and mixed fabrics of classical taste and beauty.

Group XI.

Group XI.—Jewellery, Watch Cases, Silver Ware, Bronzes, &c.

Watson & Co., Bombay, India.

Gold and Silver Jewellery.

Report.—A novel exhibition of native jewellery and ornaments in gold and silver filigree work; also native repoussé work in gold ornaments and in silver utensils, of marked excellence.

Group XVI.

Group XVI.—Military and Sporting Arms, Weapons, &c.

Government of India.

Arms.

Report.—An interesting collection of arms, selected from the India Museum.

Group XXVII.

Group XXVII.—Plastic and Graphic Art.

Watson & Co., Bombay, India.

Hammered Work in Silver, and Wood Carving.

Report.—Commended for good taste and workmanship.

Collective Exhibit.

Collective Exhibit.

Government of India.

Collective Exhibit.

Report.—A very extensive and interesting collection of articles from the India Museum in London, arranged by the Secretary of State for India.

JAMAICA.

Group III.—Chemistry and Pharmacy, including the Apparatus.

Robert Thomson, Gordon Town, Jamaica.

Essential Oils.

Report.—Commended for excellence of quality of essential oils distilled from native plants.

Government Botanical Gardens, Kingston, Jamaica.

Raw Sugar.

Report.—Commended for bright, clear products of open-pan boiling from Bog estate (Ernest Elliott), Jamaica.

Group IV.—Animal and Vegetable Products, and the Machinery for their Preparation.

F. Langier & Co., Kingston, Jamaica.

Chocolate.

Report.—Commended for its good preparation.

John McLean, Jamaica.

Coffee.

Report.—Commended for coffee of the first quality. The grains are agreeably aromatic and very well dried.

James Harrison, Jamaica.

Coffee.

Report.—Commended for the colour and aroma, and for the great size of the grains.

John Davidson, Jamaica.

Coffee.

Report.—Commended for the colour and aroma, and for the great size of the grains.

M. M. Lascelles, Jamaica.

Coffee.

Report.—Commended for the colour and aroma, and for the great and regular size of the grains.

Ernest Elliwitt, Jamaica.

Coffee.

Report.—Commended for the colour and aroma, and for the great and regular size of the grains.

Dr. Stephens, Jamaica.

Coffee.

Report.—The colour is good; the grains very small and flat.

Francis Chalmer, Jamaica.

Coffee.

Report.—Commended for the colour and aroma, and for the great size of the grains.

MR. MACLAVERTY, Jamaica.

Coffee.

Report.—Commended for the colour and aroma, and for the great size of the grains.

THE GOVERNMENT OF JAMAICA.

Coffee Neramica and Coffee-leaf Tea.

Report.—The coffee Neramica is passable as a substitute for the true coffee. The coffee-leaf tea is passable.

CHAS. GRANT, Jamaica.

Wax.

Report.—A large sample of nice bleached wax.

P. E. AUVREY, Jamaica.

Wax.

Report.—Samples of fine bleached wax.

SOUTAR & Co., Jamaica.

Leaf Tobacco and Cigars.

Report.—Leaf tobacco, in small bales, of good quality; cigars handsomely manufactured, and in great variety.

THOMPSON & WEITZMANN, Jamaica.

Leaf Tobacco.

Report.—Exceedingly well prepared, and of first quality; fine aroma.

ROBERT THOMSON, Gordon Town, Jamaica.

Preserved Fruit.

Report.—Commended for the fine flavour and good preservation of rose apple, a cheap fruit growing abundantly without cultivation.

JAMAICA CENTENNIAL COMMITTEE, Jamaica.

Fruits.

Report.—A large and varied collection of fruits, showing all the principal products of the island.

GEORGIA ESTATE, Jamaica.

Rum (G<>P).

Report.—Fine spirit, well distilled, and of remarkably fine aroma.

HORDLEY ESTATE, Jamaica.

Rum ($\frac{H.}{M.L.}$ *Crop* 1865).

Report.—Fine spirit, well distilled, and of remarkably fine aroma.

NEW WORK ESTATE, Jamaica.

Rum.

Report.—Fine spirit, well distilled, and of remarkably fine aroma.

LANSQUINET ESTATE, Jamaica.

Rum.

Report.—Fine spirit, well distilled, and of remarkably fine aroma.

Jamaica.

Group IV.

BLUECASTLE ESTATE, Jamaica.

Rum (I. W. O.)

Report.—Fine spirit, well distilled, and of remarkably fine aroma.

AMITY HALL ESTATE, Jamaica.

Rum ($\frac{A}{T.C.}$ *Crop* 1876).

Report.—Fine spirit, well distilled, and of remarkably fine aroma.

Group VI.

GROUP VI.—TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY.

ROBERT THOMSON, Superintendent of the Government Botanic Gardens, Kingston, Jamaica.

Woods and other Products.

Report.—An exceedingly valuable and interesting collective exhibit, containing fifty specimens of wood, most of them very valuable, and all well arranged and described; three varieties of cinchona bark, several valuable dye-woods, and a large and varied exhibit of medicinal and edible herbs and nuts.

Group VIII.

GROUP VIII.—COTTON, LINEN, AND OTHER FABRICS.

ROBERT THOMSON, Superintendent, Government Botanical Gardens, Gordon Town, Jamaica.

Vegetable Fibres.

Report.—Commended for the large and important collection of vegetable fibres, destined to be of great importance to manufactures.

ROBERT THOMSON, Superintendent, Botanical Gardens, Gordon Town, Jamaica.

Sisal Hemp and China Grass.

Report.—Commended for the great utility of all these fibres in the collection, especially sisal hemp, China grass, pine-apple, bamboo, lace bark, especially adapted for ornamental purposes; of novelties and good quality; utility of bamboo for paper manufacturing especially noted.

Group X.

GROUP X.—CLOTHING, FURS, INDIA-RUBBER GOODS, ORNAMENTS AND FANCY ARTICLES.

MRS. TRANCILLA NASH, Jamaica, West Indies.

Hats and Flower Lace.

Report.—Exhibits various specimens of hats and flower lace made of Spanish dogger, a kind of dry and dyed yucca leaves (*Yucca aloifolia*) and lace bark (*Lagetta lintearia*). This exhibit shows how those leaves may be made serviceable.

Group XXIX.

GROUP XXIX.—HORTICULTURE.

JAMAICA COMMISSION.

Economic Plants.

Report.—An interesting exhibit of tropical plants, chiefly economic species.

Jamaica.

Group XXXVI.

Group XXXVI.—Pomology.

Robert Thomson, Jamaica.

Tropical Fruits.

Report.—This exhibit embraced all the leading fruits of the West Indies maturing at the time of the exhibit (end of May), and was highly instructive to the Centennial visitors.

Collective Exhibit.

Collective Exhibit.

Government of Jamaica.

Collective Exhibit.

Report.—A large display of the natural products of Jamaica.

Mauritius.

Group III.

MAURITIUS.

Group III.—Chemistry and Pharmacy, including the Apparatus.

J. Wiehé, Mauritius.

Sugar.

Report.—Commended for good quality of several samples of crystallized and vesou sugar, also of some bright yellow soft sugar.

Group VIII.

Group VIII.—Cotton, Linen, and other Fabrics

J. Horne, Director, Botanic Garden, Mauritius.

Vegetable Fibres.

Report.—A large and valuable collection of vegetable fibre, destined to be of great future value as subjects of manufacture.

Collective Exhibit.

Collective Exhibit.

Government of Mauritius and Seychelles.

Collective Exhibit.

Report.—A very interesting display of the natural resources of said colonies.

New South Wales.

Group I.

NEW SOUTH WALES.

Group I.—Minerals, Mining and Metallurgy, including the Machinery.

Department of Mines, Sydney, New South Wales, Australia.

Mineralogical and Geological Collection, and Collection of Copper and Gold Ores.

Report.—Commended for the fine, large, and well-arranged collection of ores and organic remains illustrating the economic mineralogy and the palæontology of New South Wales; also for the purity of the copper, importance of the production, and the number and classification of the gold ores and tailings.

NEW SOUTH WALES SHALE AND OIL Co., Sydney, New South Wales, Australia.

Kerosene Shale and Oil.

Report.—An interesting exhibition of samples of kerosene shale, and of burning oil obtained from that kind of coal.

JOHN YOUNG, Sydney, New South Wales, Australia.

Blocks of Marble and Granite.

Report.—Commended for the good quality of the building stones exhibited.

T. BROWNE, West Maitland, New South Wales, Australia.

Blocks of Sandstone.

Report.—Commended for the good quality of the stone.

NEW SOUTH WALES COMMISSIONERS, Sydney, New South Wales, Australia.

Tin Ore, Tin Ingots, Bar Tin, and Grain Tin.

Report.—Commended for the purity of the metal and the importance of the production.

ARTHUR DEWHURST, Tamworth, New South Wales, Australia.

Tin Ores.

Report.—Commended for the choice selection and number of samples.

MOORE & Co., Sydney, New South Wales, Australia.

Tin.

Report.—Commended for the purity of the metal.

J. HAWKINS BUTCHART, Sydney, New South Wales, Australia.

Collection of Tin Ores.

Report.—Commended for a beautiful collection of tin ores, remarkable for their size and richness.

GROUP III.—CHEMISTRY AND PHARMACY, INCLUDING THE APPARATUS

C. HOFF, New Caledonia, New South Wales, Australia.

Chemicals.

Report.—Commended for quality of indigo exhibited, and for its production from native sources.

NEW SOUTH WALES SHALE AND OIL Co., Sydney, New South Wales, Australia.

Coal Oil.

Report.—Commended for the good quality of kerosene oil distilled from native shale.

ROBERTSON & Co., Botany, New South Wales.

Stearine Candles.

Report.—Commended for the good quality of the candles manufactured in a country where the industry is still but little developed; for the importance given the manufacture of stearine products.

New South Wales.

Group III.

COLONIAL SUGAR REFINING Co., Sydney, New South Wales, Australia.

Refined Sugars.

Report.—Commended for general excellence of crystallized sugars produced upon a large scale.

BIDDELL BROTHERS, Sydney, New South Wales, Australia.

Confectionery of Sugar.

Report.—Commended for the exhibition of a good assortment of bonbons, of pure material and neatly prepared from colonial sugar.

Group IV.

GROUP IV.—ANIMAL AND VEGETABLE PRODUCTS, AND THE MACHINERY FOR THEIR PREPARATION.

W. COLE & SON, New South Wales, Australia.

Arrowroot.

Report.—A product very white, pure, strong, and clear.

A. T. LAWRIE, Gloucester, New South Wales, Australia.

Arrowroot.

Report.—A product pure, white, and strong.

JAMES WATERS, Brisbane Water, New South Wales, Australia.

Arrowroot.

Report.—White, fine, and sweet.

WATSON BROTHERS, Young, New South Wales, Australia.

Flour from Winter Wheat.

Report.—Colour good, strength good; adapted for general consumption without any special qualities.

DALTON BROTHERS, Orange, New South Wales, Australia.

Flour from Winter Wheat.

Report.—Colour fine, strength fair; adapted for general consumption, without any special qualities.

LEWIS BROTHERS, Tamworth, New South Wales, Australia.

Wheat Flour from Winter Wheat.

Report.—Colour good, strength fair; adapted for general consumption, without any special qualities.

JOHN HARDIE, Sydney, New South Wales, Australia.

Biscuit and Crackers.

Report.—Commended for its well-preserved condition, indicating great skill in manufacture.

DALTON BROTHERS, Orange, New South Wales, Australia.

Wheat.

Report.—Commended for good weight and fine appearance.

Sir William MacArthur, Camden, New South Wales, Australia.

Corn.

Report.—Commended for good weight and appearance of three varieties of Indian corn.

W. Schweigert, Sydney, New South Wales, Australia.

Cigars.

Report.—Well manufactured of native tobacco; good quality for price.

C. Hoff, New Caledonia, New South Wales, Australia.

Canned Fruits.

Report.—Pine-apple preserved whole; good fruits with excellent flavour.

Sydney Meat Preserving Co., Sydney, New South Wales, Australia.

Preserved Meats.

Report.—The ox-tongue and boiled beef are carefully put up, well preserved, and of good taste.

Barrett & Co., Sydney, New South Wales, Australia.

Syrups and Extracts.

Report.—Commended for careful preparation, natural taste, and good condition.

James T. Fallon, Albury, New South Wales, Australia.

Australian Wines.

Report.—Commended for the fine flavour and good style of some of the samples submitted.

Carl J. P. Brecht, Rosemount, Denmann, New South Wales, Australia.

Australian Wines.

Report.—Commended for the good style and quality of the Muscatel and Riesling.

Alexander Munro, Singleton, New South Wales, Australia.

Australian Wines.

Report.—Commended for the very fine condition of his light-bodied wines.

Wadham Wyndham, Bukkulla, New South Wales, Australia.

Australian Wines.

Report.—Commended for good condition and quality.

J. F. Doyle, Kaludah, New South Wales, Australia.

Australian Wines.

Report.—Commended for good quality and condition, showing the careful treatment of the wines.

Group VI.—Timber, Worked Lumber, Parts of Buildings, Forestry.

New South Wales Commissioners.

Woods and Timbers of New South Wales, with Barks.

Report.—Commended for the comprehensiveness of the exhibit, as well as size, beauty, and manner of exhibiting the specimens. This exhibit consists

New South Wales. Group VI.

of one hundred and ninety-five species, accompanied with the scientific and common names, their natural orders, with remarks on the size, uses, character, and localities of the trees. Many of the specimens are of large size. Also, seeds, ginger-root, and barks.

HUDSON BROS., Sydney, New South Wales, Australia.

Doors and Table-legs.

Report.—Commended for workmanship, durability, and moderate prices, also beauty of woods used in construction.

Group VIII.

GROUP VIII.—COTTON, LINEN, AND OTHER FABRICS.

E. W. RUDDER, Kempsey, New South Wales, Australia.

Fibre of gigantic Nettle Tree.

Report.—Fibre of gigantic nettle tree and bark of sycamore tree. Commended for discovery of fibre and adaptation for trade purposes, utility thereof, comparative smoothness.

J. C. READ, Governor of the Darlinghurst Gaol, Sydney, New South Wales, Australia.

Matting, made by the Aborigines.

Report.—Commended for excellence in quality and variety of product.

Group IX.

GROUP IX.—WOOL AND SILK FABRICS, WITH THE MACHINERY.

GEORGE THORNE, Sydney, New South Wales, Australia.

Silk Cocoons.

Report.—A good assortment of cocoons of different races; commendable, considering the youth of the plantation.

SUPERINTENDENT OF DESTITUTE CHILDREN'S ASYLUM, Sydney, New South Wales, Australia.

Silk Cocoons.

Report.—A fine show of cocoons; very creditable as first essays.

F. R. WHITE, Blandford, New South Wales, Australia.

Wool.

Report.—Commended for combing merino wool, of superior growth and quality; also for several fleeces of Saxon merino wool, of excellent growth and staple.

J. B. BETTINGTON, Merrieva, New South Wales, Australia.

Wool.

Report.—Commended for two cases of Saxon merino combing wool, of fine quality, good staple and growth; also for greasy wool, of very superior quality and merit.

G. H. COX, Mudgee, New South Wales, Australia.

Wool.

Report.—An extensive and excellent exhibit of Saxon merino combing wool beautifully washed, of the finest quality, and very high merit.

HENTY & BALFOUR, Albury, New South Wales, Australia.

Wool.

Report.—Two cases of combing merino wool, of very superior quality and growth, and excellent in every respect.

E. K. COX, Mudgee, New South Wales, Australia.

Wool.

Report.—Several fleeces of Saxon merino combing wool, well washed, of excellent quality, fibre, and staple, and of very high merit.

E. & A. TINDAL, Barrajan, New South Wales, Australia.

Wool.

Report.—Commended for fine washed combing Saxon merino wool, of very superior quality and fibre, and of high merit; also for greasy combing wool of superior quality.

G. L. LETHBRIDGE, Singleton, New South Wales, Australia.

Wool.

Report.—Cases of Saxon merino greasy combing wool, of good fibre and quality.

A. N. GILBERT, Warwillah, New South Wales, Australia.

Wool.

Report.—Saxon merino combing wool, of fine quality, good staple, and healthy growth.

E. & A. BOWMAN, Rotherwood, New South Wales, Australia.

Wool.

Report.—Commended for greasy merino clothing wool, of superior quality and adapted for fine cloths; also for several cases of Saxon merino combing wool, of good quality and fibre.

T. BROWN & Co., Tuppal, New South Wales, Australia.

Wool.

Report.—Cases of excellent combing merino wool, of first-rate quality, and if free from burrs, would be most choice wool.

JOHN MCVEAN, Wooloomoonoo, New South Wales, Australia.

Merino Wool.

Report.—Combing merino wool, of fine fibre and staple and very superior quality.

ANDREW LODER, Colley Creek, New South Wales, Australia.

Wool.

Report.—Commended for an excellent exhibit of fine merino clothing wool, of superb quality, and adapted for the manufacture of the best superfine cloths; also for combing merino wool, of very choice quality, staple, and fibre.

A. H. LOWE, Dynevor, New South Wales, Australia.

Wool.

Report.—Angora goats' wool of fine growth and high lustre, adapted for the manufacture of mohair fabrics; capable of further improvement.

JOHN ALLEN, Burrangong, New South Wales, Australia.

Wool.

Report.—One case of Saxon merino combing wool, of very fine quality and good staple; also well bred.

WM. LANG, Wargam, New South Wales, Australia.

Wool.

Report.—Excellent samples of greasy wether and hogget wool, of very superior quality and staple.

F. & A. COX, Mudgee, New South Wales, Australia.

Wool.

Report.—A very superior exhibit of fine Saxon merino combing wool, excellent in quality and fibre.

D. H. CAMPBELL, Cunningham Plains, New South Wales, Australia.

Wool.

Report.—Commended for one case of Rambouillet combing wool of superior quality, healthy growth, and good staple; also for clothing wool adapted for fine cloths.

W. A. BRODRIBB, Moolbong, New South Wales, Australia.

Wool.

Report.—Fine combing merino wool, of good staple and quality, and adapted for the manufacture of cassimeres.

L. LEARMONTH, Groongal, New South Wales, Australia.

Wool.

Report.—Cases of fine combing merino wool, of excellent quality, fibre, and growth; a most choice selection.

E. B. HULME, Burrowa, New South Wales, Australia.

Wool.

Report.—Saxon merino combing wool in the grease, of good fibre, quality, and growth; also very heavy fleeces.

P. G. KING, Goonoo Goonoo, New South Wales, Australia.

Wool.

Report.—Several fleeces of superior combing merino wool, excellent in quality and staple.

CLIVE & HAMILTON, Collaroy, New South Wales, Australia.

Wool.

Report.—A very superior exhibit of beautifully washed merino combing wool, of the highest quality, and excellent in every respect; also combing wool of choice quality.

ALEXANDER WILSON, Coree, New South Wales, Australia.

Wool.

Report.—Fleeces of merino combing wool, of excellent growth and quality, and adapted for combing purposes; very choice in every respect.

SAMUEL MCCAUGHEY, Coonong, New South Wales, Australia.

Wool.

Report.—One case of combing merino wool, of very superior quality and good staple; also beautifully washed.

J. VICARS, Sydney, New South Wales, Australia.

Tweeds, Plaids, and Shawls.

Report.—Tweeds, plaids, and shawls, of honest and substantial manufacture, made of domestic wool, and very creditable for a new country.

GROUP X.—CLOTHING, FURS, INDIA-RUBBER GOODS, ORNAMENTS AND FANCY ARTICLES.

P. A. JENNINGS, Sydney, New South Wales, Australia.

Furs.

Report.—His exhibit consists of a muff, collarette, and pair of cuffs, very neatly made from the skins of the platypus; also two stuffed platypus skins, male and female. Commended for specialty, novelty, and good workmanship.

GROUP XII.—LEATHER AND MANUFACTURES OF LEATHER.

ALDERSON & SONS, Sydney, New South Wales, Australia.

Japanned and Enamelled Split Hides for Carriage and Saddlery Work; Enamelled Kangaroo Skins for Boots and Shoes.

Report.—Commended for the skilled workmanship evinced in the leather, which is well tanned and worked, the japanning being very good; specially worthy of mention as evincing progress in this industry in a new country.

WRIGHT, DAVENPORT, & Co., Sydney, New South Wales, Australia.

Sole Leather and Enamelled and Russet Kangaroo Skins for Boots and Shoes.

Report.—The leather is thoroughly and well tanned, and is tough and pliable. The enamel is of good colour, and is tough and durable. The product evinces skilled workmanship and the realization of the resources of a new country. The sole leather is good, solid, and well tanned, and evinces thorough skill in the manufacture.

GROUP XIII.—PAPER, STATIONERY, PRINTING AND BOOKMAKING.

THOMAS RICHARDS, Sydney, New South Wales, Australia.

Blank Books, Bookbinding, and Printing.

Report.—The entire work is of a creditable and praiseworthy character.

GROUP XVII.—CARRIAGES, VEHICLES, AND ACCESSORIES.

P. GUERIN, Sydney, New South Wales, Australia.

Saddles.

Report.—Commended for good substantial work and low prices.

New South Wales.

Group XX.

Group XX.—Motors, Hydraulic and Pneumatic Apparatus.

T. D. Postle, Sydney, New South Wales, Australia.

Portable Ice Maker and Water Cooler.

Report.—Commended as a simple and useful machine for hot climates.

Group XXIV.

Group XXIV.—Medicine, Surgery, and Prothesis.

John Spencer, Sydney, New South Wales, Australia.

Mechanical Dentistry.

Report.—Commended for excellence of workmanship.

Group XXVI.

Group XXVI.—Architecture and Engineering.

Government of New South Wales, Australia.

Maps of New South Wales.

Report.—Commended for the plain way in which the various features of the country, agricultural, mineral, &c., are delineated.

James Barnet, Sydney, New South Wales, Australia.

Architectural Designs.

Report.—Commended for beauty of designs and good treatment of subjects.

Group XXVII.

Group XXVII.—Plastic and Graphic Art.

J. Hubert Newman, Australia.

Photographs.

Report.—Commended for portrait photographs.

B. O. Haltemann, Sydney, New South Wales, Australia.

Photographs.

Report.—Commended for large panoramic photographs.

John Sharkey, Sydney, New South Wales, Australia.

Photographs.

Report.—Commended for photo-lithography.

W. T. Lindt, Grafton, New South Wales, Australia.

Photographs.

Report.—Commended for good landscape photographs.

Group XXVIII.

Group XXVIII.—Education and Science.

Thomas Richards, Sydney, New South Wales.

Meteorological Results, and Report on Education.

Report.—Commended for good printing of interesting and valuable publications.

Collective Exhibit.

New South Wales.

Collective Exhibit.

Government of New South Wales, Australia.

Collective Exhibit.

Report.—Commended for a trophy of coal, illustrating, in full size, sections of the four principal coal fields, and also number and locality of the different mines.

For a trophy representing the exact bulk of the total quantity of gold raised in the State from 1851 to 1874.

For samples of gold from forty-eight different fields, with various assays showing weight, value, percentage of silver, &c. &c.

For sixty-five boxes of wool of high quality, collected from different localities by the Commission.

For forty samples of wines from different vineyards of the country, collected by the Commission.

For one hundred and fifty-eight photographic views of Sydney and surrounding country.

For a very fine collection of tin ores, from twenty different mines, arranged by Mr. Dutchart.

NEW ZEALAND.

New Zealand.

Group I.

Group I.—Minerals, Mining and Metallurgy, including the Machinery.

Colonial Museum, Wellington, New Zealand.

Collection of Minerals.

Report.—An instructive collection of rocks and minerals from New Zealand, arranged by Dr. James Hector.

Group III.

Group III.—Chemistry and Pharmacy, including the Apparatus.

Walker, Renwicks, & Co., Auckland, New Zealand.

Kauri Gum.

Report.—Commended for excellence of display of different qualities of Kauri gum, including some of exceptional merit.

W. S. Grayling, Taranaki, New Zealand.

Wood Extracts.

Report.—Commended for the quality of extracts applicable to the tanning of leather.

Group IV.

Group IV.—Animal and Vegetable Products, and the Machinery for their Preparation.

E. H. Banks, Christchurch, New Zealand.

Cereals.

Report.—Commended for fine weight and appearance of rye and barley and oats of the most excellent quality.

Robert Wilkens, Christchurch, New Zealand.

Grass Seed.

Report.—Beautiful samples of rye grass and cocksfoot grass seed.

New Zealand.

Group IV.

P. Cunningham & Co., Christchurch, New Zealand.

Wheat.

Report.—Commended for the very fine appearance and very great weight of four varieties of wheat.

W. D. Wood, Christchurch, New Zealand.

Wheat.

Report.—Commended for the fine appearance and good weight of four varieties.

Henderson & Farran, Wellington, New Zealand.

Ale and Stout.

Report.—Several samples, all showing good brewing, fair condition, careful treatment, and variety enough to suit all tastes.

James Smith, Nelson, New Zealand.

Fruit-wines from Gooseberries, Apples, Plums, Cherries, &c.

Report.—Wines from several fruits and berries, well blended and composed, very tasteful and palatable, and kept in excellent condition.

Group VI.

Group VI.—Timber, Worked Lumber, Parts of Buildings, Forestry.

John Chambers, Auckland, New Zealand.

Pressed Ferns.

Report.—Commended for the beauty and interest of the exhibit, which consists of fifty-four species of ferns collected in the Auckland Province, artistically arranged, mounted, and framed.

Dr. Hector, Director of the Colonial Museum, New Zealand.

Barks for Tanning.

Report.—The collection includes eight barks and one wood used or tested for tanning in New Zealand. Dr. Hector has carefully determined the amount of tannin in each of these by a laborious and important investigation.

The Colonial Commission of New Zealand, by Dr. Hector.

Samples of Kauri Gum.

Report.—This collection embraces a large number of specimens of kauri gum, some of great size, representing eight varieties of gum. It is the only important exhibit of kauri gum in the Exhibition.

Group VIII.

Group VIII.—Cotton, Linen, and other Fabrics.

Dr. James Hector, Wellington, New Zealand.

Vegetable Fibres and Fabrics.

Report.—Commended for the large and valuable collection of fibres of vegetable origin, with samples of the fabrics produced therefrom, especially of the "phormium tenax" or New Zealand flax, indicating the direction of a new and important industry.

COMMISSIONERS OF NEW ZEALAND.

Phormium.

Report.—A general collection of the fibre, illustrating all manner of preparation and applications for the manufacture of rope, cordage, yarn, cloth, and paper. Commended for great labour and pains, and for economy and quality of the different products.

CHARLES CHINNERY, Addington, Canterbury, New Zealand.

Phormium Fibre.

Report.—Commended for excellent quality of fibre for roping purposes, great strength, careful preparation.

GROUP IX.—WOOL AND SILK FABRICS, WITH THE MACHINERY.

W. S. PETER, Canterbury, New Zealand.

Wool.

Report.—Merino fleece wool, of very choice quality, good fibre, and staple.

SAMUEL BEALEY, Canterbury, New Zealand.

Wool.

Report.—Several fleeces cross-merino ewe wool, by Romney Marsh or Kent ram, of very choice quality and good weight.

JOHN HALL, Canterbury, New Zealand.

Wool.

Report.—Merino fleece wool, of very superior quality and growth.

GEO. A. ANSTEY, Nelson, New Zealand.

Wool.

Report.—Several fleeces of merino ram and ewe wool, of choice quality and excellent growth.

J. CATHCART WASON, Canterbury, New Zealand.

Wool.

Report.—Commended for several fleeces of merino wether wool, and for Lincoln fleeces, of good staple and quality.

A. BRAITHWAITE, Wellington, New Zealand.

Wool.

Report.—Romney Marsh and merino fleece wool, of good quality and growth.

A. H. RICKMAN, Canterbury, New Zealand.

Wool.

Report.—Romney Marsh ewe wool, very silky, and of healthy growth.

New Zealand.

Group X.

Group X.—Clothing, Furs, India-rubber Goods, Ornaments and Fancy Articles.

Hector Evelyn Liardet, Wellington, New Zealand.

Feather Furs.

Report.—A variety of ladies' muffs, tippets, and cuffs, made from the skins of white, mottled, gray, and brown albatross, the white-back ganol, and the gray, green, and speckled cormorant. Commended for specialty, novelty, good work, durability, and cheapness.

Group XVI.

Group XVI.—Military and Sporting Arms, Weapons, &c.

Colony of New Zealand.

Weapons and Clothing.

Report.—An interesting collection of aboriginal (Maori) weapons and clothing, made for the commissioners of New Zealand by Mr. R. W. Woon, R.M.

Group XXVI.

Group XXVI.—Architecture and Engineering.

Government of New Zealand.

Geological Maps and Charts of the Iron Studies.

Report.—From their completeness, these works are worthy of consideration.

Group XXVII.

Group XXVII.—Plastic and Graphic Art.

John Chambers, New Zealand.

Photographs.

Report.—Commended for photographs of the geysers.

Group XXVIII.

Group XXVIII.—Education and Science.

Dr. James Hector, Director Geological Survey of New Zealand.

Geological Reports, Maps, Sections, and Reliefs.

Report.—Commended for the efficiency of his survey and the value of its results, as shown by reports and other interesting exhibits.

The Government of New Zealand.

Topographical and Geological Maps of New Zealand; Ethnological Collection exhibited by the Commissioners and by the Colonial Museum.

Report.—Commended for its interesting representation of the resources and progress of New Zealand, as well as for its encouragement of education and scientific research.

The New Zealand Institute, New Zealand.

Volumes I. to VII. of Transactions and Proceedings.

Report.—Commended for the zeal and scientific value of a work early commenced and vigorously carried on. That peculiar feature of the Institute which consists in its holding the position of central and parent organization to several local societies, whose scientific papers if approved are published in its Transactions, is worthy of adoption elsewhere.

COLLECTIVE EXHIBIT.

New Zealand.

GOVERNMENT OF NEW ZEALAND.

Collective Exhibit.

Collective Exhibit.

Report.—Commended for a large and superior collection, showing the vast natural wealth and productive industry of this colony.

QUEENSLAND.

Queensland.

GROUP I.—MINERALS, MINING AND METALLURGY, INCLUDING THE MACHINERY.

Group I.

MRS. BISHOP, Barcoo, Queensland, Australia.

Collection of Opals.

Report.—A remarkable collection of opals from the Barcoo.

RICHARD DAINTREE, Holyrood House, Queensland, Australia.

Geological Collection.

Report.—A collection of rocks, ores, and organic remains from Queensland, with an instructive comparison between the rocky strata and the overlying soils.

COMMISSIONERS OF QUEENSLAND, Australia.

Coals.

Report.—Commended for good quality.

THE COLONY OF QUEENSLAND, Australia.

Gold.

Report.—Commended for the choice specimens and the number exhibited.

W. C. HUME, Stanthorpe Mines, Queensland, Australia.

Tin Ores.

Report.—Commended for the number and the choice exhibit of the samples.

BULIMBA SMELTING CO., Brisbane, Queensland, Australia.

Tin.

Report.—Commended for the purity and the quantity of the tin bars exhibited.

BENTINCK TIN MINING CO., Queensland, Australia.

Tin Ores.

Report.—Commended for the quality of the ores and illustrations of the alluvial deposits in which the same are found.

NORMANBY COPPER MINING CO., Mt. Perry, Queensland, Australia.

Copper Ores.

Report.—A large and valuable exhibit of copper ores.

PEAK DOWNS COPPER CO., Peak Downs Mine, Queensland, Australia.

Copper Ingot.

Report.—Commended for the purity of the metal.

Queensland. Group I.

MOUNT PERRY COPPER MINING Co., Mt. Perry District, Queensland, Australia.

Copper.

Report.—Commended for purity of the metal.

A. C. GREGORY, St. John's Creek, Burnett District, Queensland, Australia.

Regulus of Antimony.

Report.—Commended for the good quality of the samples of antimony regulus.

Group III. GROUP III.—CHEMISTRY AND PHARMACY, INCLUDING THE APPARATUS.

J. F. DAVIDSON, Alexandra Plantation, Mackay, Queensland, Australia.

Raw Sugar.

Report.—An excellent exhibit of a very dry, almost white, coarse-grained, rich, raw sugar, obtained by evaporation in an open pan. Commended for excellence in manipulation and product.

A. H. BROWN, Maryborough, Queensland, Australia.

Raw Sugar.

Report.—The raw sugar obtained by evaporation in vacuum-pans is almost white, of good, fine grain, and rich and excellent quality. Commended for excellence of product.

FRYAR & STRACHAN, Loganholm, Queensland, Australia.

Raw Sugar.

Report.—A very fine, rich, coarse-grained, yellowish-white, dry, raw sugar. Commended for excellence of product.

JOHN MCDONALD, Supt. Government Penal Establishment, St. Helena, Queensland, Australia.

Raw Sugar.

Report.—A yellowish-white raw sugar, of good grain and richness, obtained by evaporation in an open pan, which shows great skill in manipulation. Commended for excellence of product.

JNO. CHING, Queensland, Australia.

Dugong Oils.

Report.—The oil from the dugong of fine quality, being free from smell or taste after the heat of summer, and well adapted to the same purposes as cod-liver oil, and less nauseous.

ANGUS MACKAY, Queensland, Australia.

Eucalyptus Gums.

Report.—Commended for a rare and valuable exhibit of medicinal gums.

ANGUS MACKAY, Queensland Commission.

Tanning Barks.

Report.—Commended for bark possessing a large amount of tannin.

GROUP IV.—ANIMAL AND VEGETABLE PRODUCTS, AND THE MACHINERY FOR THEIR PREPARATION.

W. MARKS, Tweed River, Queensland, Australia.

Arrowroot.

Report.—A product very white and pure, of excellent clearness and strength.

HENRY LANE, North Pine, Queensland, Australia.

Arrowroot.

Report.—A product pure, strong, and sweet.

F. KEATS, Allora, Queensland, Australia.

Graham Flour.

Report.—Colour very fine; splendidly milled.

NEDEN BROTHERS, Toowoomba, Queensland, Australia.

Flour from Winter Wheat.

Report.—Colour fine, strength fair; adapted for general consumption, without any special qualities.

GEORGE DOWN, Darling Downs, Queensland, Australia.

Barley.

Report.—Commended for fine appearance and good curl.

J. H. BOREHAM, South Brisbane, Queensland, Australia.

Chutney and Tomato Catsup Sauces.

Report.—The Chutney and tomato catsups are very well prepared and very well flavoured.

J. E. DAVIDSON, Mackay, Queensland, Australia.

Rum.

Report.—The best and the least fiery of the several exhibits of rum of the same colony, showing more careful distillation; a very good flavour.

ALEXANDER MCPHERSON, Brisbane, Queensland.

Australian Fibres.

Report.—Commended for an interesting exhibit of various kinds, among which the Sida Retusa may be specially mentioned for its properties resembling hemp.

W. H. HAYES, Queensland.

Candied Australian Fruits.

Report.—Commended for good quality, having stood the test of a hot summer, unchanged.

GROUP VI.—TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY.

WALTER HILL, Director of Botanic Gardens, Brisbane, Queensland, Australia.

Woods and Timber.

Report.—The exhibitor shows two fine collections, one a botanical collection of woods, with the name and uses on each specimen, and the other a large commercial exhibit of Queensland timbers.

Queensland.

Group VI.

P. A. O'Shanesy, Rockhampton, Queensland, Australia.

Sections of Forest Trees.

Report.—This collection, though not large, is meritorious as being a fine local exhibit, and contains some beautiful and valuable specimens.

F. N. Bailey, Queensland, Australia.

Botanical Collection: Plants of Queensland.

Report.—Commended for the magnitude of the collection, and the neatness and accuracy with which they have been classified and mounted.

J. C. Baird, Cooktown, Queensland, Australia.

Wattle Bark for Tanning.

Report.—Commended as a good exhibit.

Group VII.

Group VII.—Furniture, Upholstery, Woodenware, Baskets.

C. M. Carey, Queensland, Australia.

Work-box of curious Woods.

Report.—Commended for very good workmanship.

Group VIII.

Group VIII.—Cotton, Linen, and other Fabrics.

Commissioners for Queensland, Australia.

Vegetable Fibres.

Report.—A large and interesting collection of fibres of vegetable origin, destined to be of great future importance in manufactures.

Government of Queensland, Australia.

Raw Cotton.

Report.—Eight small samples of upland cotton, well handled, and fair staple.

Angus Mackay, Queensland, Australia.

Raw Cotton.

Report.—An exhibit of cotton grown from American seed, cultivated by himself, of excellent quality.

Group IX.

Group IX.—Wool and Silk Fabrics, with the Machinery.

C. F. Chubb, Ipswich, Queensland, Australia.

Raw-silk Cocoons.

Report.—Good variety of raw-silk cocoons of different races.

John McDonald, Queensland, Australia.

Silk Cocoons.

Report.—A very creditable assortment of raw-silk cocoons of good quality.

Fenwick & Scott, Queensland, Australia.

Wool.

Report.—A large collection of samples of Australian wool, most of which are of high merit, great length of staple, and superior quality.

L. E. Lester, Rosenthal, Queensland, Australia.

Merino Wool.

Report.—Australian merino wool, of superior quality, and in fine condition.

G. H. Davenport, Headington Hill, Queensland, Australia.

Wool.

Report.—A most choice exhibit of merino combing wool of the finest quality, long staple, and excellent in every respect; especially remarkable for its length and richness of fibre.

Shanahan & Jennings, Westbrook Station, Queensland, Australia.

Wool.

Report.—A very excellent exhibit of Australian merino wool, choice in every respect.

C. B. Fisher, Headington Hill, Queensland, Australia.

Merino Wool.

Report.—Well-bred merino wool, of exceedingly fine quality, good staple, and growth.

B. C. Parr, Queensland, Australia.

Australian Wool.

Report.—Australian wool, of superior quality and in good condition, high class wool in every respect.

George Clark, East Talgai, Queensland, Australia.

Merino Wool.

Report.—Australian merino wool, of very superior quality and fibre, and of high merit.

Gore & Co., Yandilla, Queensland, Australia.

Merino Wool.

Report.—A very good exhibit of merino wool, of fine quality, good staple, and healthy growth.

Simpson & Co., Bon Accord, Queensland, Australia.

Wool.

Report.—Combing merino wool, of very superior quality, staple, and growth.

Charles Clark, Queensland, Australia.

Angora Wool.

Report.—Fleece of pure Angora wool, of excellent quality, good staple, and rich lustre.

Marshall & Slade, Glengallan, Queensland, Australia.

Merino Wool.

Report.—A very creditable exhibit of merino wool, one fleece of which is from Champion ram. The wool is choice in every respect.

C. H. Green, Goomburra, Queensland, Australia.

Merino Wool.

Report.—Australian merino wool, of first-rate quality, and in excellent condition.

Queensland.

Group XII.

Group XII.—Leather and Manufactures of Leather.

T. B. Stephens, Ekibin Tannery, Queensland, Australia.

Black-grained and Wax Kip; Kangaroo and Goat Skins in different Finishes.

Report.—Commended for the skill and enterprise evinced; the industry, being quite new in this country, is entitled to mention for the progress made.

Group XIII.

Group XIII.—Paper, Stationery, Printing, and Bookmaking.

James Beal, Queensland, Australia.

Blank Books, Printing, and Binding.

Report.—The blank books are well made, and the printing and binding are in the highest degree creditable.

GroupXVII.

Group XVII.—Carriages, Vehicles, and Accessories.

Sheriff of Queensland, Australia.

Stockman's and Gentleman's Mountain Saddles; also One Pack-saddle.

Report.—Good useful work, and well adapted to the intended use.

Group XXVI.

Group XXVI.—Architecture and Engineering.

Government of Queensland, Australia.

Maps of Queensland.

Report.—Commended for the admirable manner in which the mineral lands are shown at a glance.

Group XXVII.

Group XXVII.—Plastic and Graphic Art.

Richard Daintree, Queensland, Australia.

Photographs.

Report.—Commended for coloured photographs of landscapes and objects of scientific interest.

Group XXVIII.

Group XXVIII.—Education and Science.

J. Behland, Queensland, Australia.

Case of Insects.

Report.—For great beauty and finish, exhibiting great taste in the arrangement of the colors of the insects.

Angus Mackay, Brisbane, Queensland, Australia.

Works on "Tropical Agriculture" and the Sugar-Cane in Australia.

Report.—Commended for comprehensive treatment of the above-mentioned subjects, and their applications in Australia.

COLLECTIVE EXHIBIT. Collective Exhibit.

GOVERNMENT OF QUEENSLAND, Australia.

Collective Exhibit.

Report.—Commended for a large and superior collection, showing the vast natural wealth and productive industry of this colony.

SOUTH AUSTRALIA.

GROUP I.—MINERALS, MINING AND METALLURGY, INCLUDING THE MACHINERY.

R. S. CRABB, Adelaide, South Australia.

Block of Malachite, Burra-Burra Mine.

Report.—Commended for beauty of colour and texture.

COORONG OIL AND COAL CO., Adelaide, South Australia.

An Asphalt called Coorongite.

Report.—Commended for a material used in manufacturing mineral oil, paraffine, &c.

COMMISSIONER OF COPPER MINES OF SOUTH AUSTRALIA.

Copper Ore and Copper.

Report.—Commended for the number and variety of ores and purity of the metal extracted; the copper ores are produced by the North Yelta, Dalbannab, Wallarous, Moonta, Durra, and adjacent mines.

GROUP III.—CHEMISTRY AND PHARMACY, INCLUDING THE APPARATUS.

SAMUEL DAVENPORT, Adelaide, South Australia, Australia.

Olive Oil.

Report.—The olive oil exhibited is of excellent quality, bland and free from any disagreeable taste or smell, manufactured partly from the fruit of imported French olives, partly from seedlings. This appears to represent the commencement, upon a moderate scale, of an important colonial industry promising excellent results.

GROUP IV.—ANIMAL AND VEGETABLE PRODUCTS, AND THE MACHINERY FOR THEIR PREPARATION.

SOUTH AUSTRALIAN COMMISSION.

Cereals and Grasses.

Report.—A fine collection of grains, grasses, and farm seeds.

EDWARD M. BAGOT, Adelaide, South Australia, Australia.

Dry Extract of Meat.

Report.—Commended for the following reasons:

1. Very good flavour.
2. Compactness.
3. Good preservation.

South Australia.

Group IV.

GEORGE MCEWEN & SON, Adelaide, South Australia, Australia.

Preserved Fruits.

Report.—Commended for the variety and excellence of a collection of jams and marmalades.

THOMAS HARDY, Adelaide, South Australia, Australia.

Preserved Fruits.

Report.—Three varieties of raisins, Muscatels, and sultana; all good in quality of fruit and in preparation.

F. WURM, Adelaide, South Australia, Australia.

Preserved Fruits.

Report.—Commended for variety and general excellence of flavour and condition of raisins, figs, and other sub-tropical fruits.

F. C. DAVIS, Adelaide, South Australia, Australia.

Liquors.

Report.—An assortment of very good cordials, bitters, and brandies, showing good taste and careful distilling.

SAMUEL DAVENPORT, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good condition, clean taste, and pleasant style of some Beaumont wines.

JOS. GILBERT, Pernsey Vale, South Australia, Australia.

Wine.

Report.—Commended for the good quality and pleasant style of some Riesling wines.

THOS. HARDY, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good quality of different wines.

ALEX. C. KELLY, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good flavour and quality of 1873 claret.

G. F. IND, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good quality and condition of a Shiraz and Madeira, 1872 vintage.

EDWARD THORNBER, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the excellent rich style and quality of a Pedro Ximenes, 1871 vintage.

J. W. WEIGHT, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good quality of 1873 Muscatel.

J. D. Holbrook, Adelaide, South Australia, Australia.

Wine.

Report.—Commended for the good quality of a sherry wine; rich in body, pleasant in style.

Jos. Gillard, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the superior quality, good condition, and style of a Frontignac, 1874 vintage.

John H. Kaines, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good quality and condition of an 1871 vintage Verdeilho.

R. D. Ross, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for good quality.

J. M. Richmann, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good quality of an 1870 and 1871 vintage Grenache, and 1870 Shiraz.

C. A. Hornbrook, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good quality of a "Palomino blanco," 1867 vintage.

George White, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good quality and condition of an 1871 vintage Pedro Ximenes, and of a Pommard.

Isabella Baker, Adelaide, South Australia, Australia.

Wine.

Report.—Commended for the superior quality and style of some Monalta wines.

Patrick Auld, Adelaide, South Australia, Australia.

Wines.

Report.—Commended for the good quality of some Auldana wines exhibited.

W. Salter & Son, Adelaide, South Australia, Australia.

Wines.

Report.—A very superior liqueur-wine, 1870; vintage Shiraz.

Commissioners of South Australia, Australia.

Wines.

Report.—A selected assortment of the best Australian wines, among which some "Riesling," "Frontignac," "Monalta," and "Port" wines, and particularly of 1870 vintage "Ardeilha," were found superior, giving proof of a continued improvement in the culture of vineyards and of wines.

South Australia.

Group IV.

HENRY FOOT, Adelaide, South Australia, Australia.

Wines.

Report.—Some of the Riesling wines were found superior in flavour and good in style and condition.

Group IX.

GROUP IX.—WOOL AND SILK FABRICS, WITH THE MACHINERY.

FREDR. WURM, Adelaide, South Australia, Australia.

Silk Cocoons.

Report.—A very good exhibit of cocoons, remarkable for such a short period of culture. The yellow silk shows great tenacity, and is very clean.

WILLIAM KEMP, Adelaide, South Australia, Australia.

Wool.

Report.—Twelve sheep-skins of excellent growth and quality; very good of their kind.

HAYWARD, ARMSTRONG, & Co., Adelaide, South Australia, Australia.

Wool.

Report.—A very good selection of merino ewe, wether, hogget, and lambs' wool, all of superior quality and merit.

JOHN HOWARD ANGUS, Adelaide, South Australia, Australia.

Wool.

Report.—Commended for scoured merino lambs' wool, of fine quality and in good condition; also for two cases of show wool of choice quality, and for dressed skins of pure Lincoln ram, clean and of good staple.

ALLAN MCFARLANE, Adelaide, South Australia, Australia.

Wool.

Report.—Merino ewe wool, of good fibre, staple, and quality.

PRICE & BROWNE, Adelaide, South Australia, Australia.

Wool.

Report.—Merino ewe, wether, hogget, and lambs' wool of fine quality, good fibre, and healthy growth.

JOHN MURRAY, Adelaide, South Australia, Australia.

Merino Wool.

Report.—A choice selection of combing merino rams' wool, of long staple and excellent quality, some fleeces weighing fifteen pounds.

JOSEPH KEYNES, Keyneton, South Australia, Australia.

Merino Wool.

Report.—Four fleeces of combing merino wool, of healthy growth, good staple, and superior quality.

W. CROZIER, Adelaide, South Australia, Australia.

Wool.

Report.—Merino ewe wool of good staple, quality, and growth.

Group X.—Clothing, Furs, India-rubber Goods, Ornaments and Fancy Articles.

South Australia. Group X.

Henry Steiner, Adelaide, South Australia, Australia.

Silver-mounted Emu Vases and Ornaments.

Report.—Silver-mounted emu vases and ornaments of good make and original taste, although damaged by shipwreck. Commended for taste and originality.

Group XI.—Jewellery, Watch Cases, Silver Ware, Bronzes, &c.

Group XI.

Henry Steiner, Adelaide, South Australia.

Silver Products.

Report.—An exhibition of native silver work, vases, and inkstands, ingeniously combined in mounting the eggs of the emu.

J. M. Wendt, Adelaide, South Australia.

Silver Ware.

Report.—Commended for fancifully combining the egg of the emu in ornamental silver work as an inkstand.

Group XXVIII.—Education and Science.

Group XXVIII.

Dr. Schomburgh, South Australia, Australia.

Herbarium of South Australian Plants.

Report.—Commended for a well-prepared and extensive collection of Australian plants accurately named and embracing many rare species.

F. G. Waterhouse, Adelaide, South Australia, Australia.

Systematic Exhibit of the Natural History of South Australia.

Report.—Commended for variety of species of Australian animals, and skill manifested in mounting and grouping them.

Group XXIX.—Horticulture.

Group XXIX.

South Australian Commissioners, Adelaide, South Australia, Australia.

Wax Models of Fruits.

Report.—Good reproductions of fruits, especially those of tropical and semi-tropical species and varieties.

Collective Exhibit.

Collective Exhibit.

Government of South Australia, Australia.

Collective Exhibit.

Report.—Commended for the collective exhibit of wines, consisting of one hundred and fourteen samples; also an exhibit of marble, slate, and freestone; also a collection of statistics, and a history of the resources and productions of the colony.

Straits Settlements.

STRAITS SETTLEMENTS.

Group VI.

Group VI.—Timber, Worked Lumber, Parts of Buildings, Forestry.

Behn, Meyer, & Co., Singapore, English Colonies.

Gutta-percha.

Report.—An excellent collection of gutta-percha (raw) of various qualities.

Tasmania.

TASMANIA.

Group I.

Group I.—Minerals, Mining and Metallurgy, including the Machinery.

Commissioners of Tasmania.

Report.—Collections of ores and rocks.

Australian Slate Co., Tasmania.

Roofing and School Slates.

Report.—Commended for good quality of slate.

W. A. Kermoda, Mona Vale, Tasmania.

Blocks of Sandstone.

Report.—Commended for the good quality and colour of the stone.

Mount Bischoff Tin Mining Co., Mount Bischoff, Tasmania.

Tin Ores and Tin in Ingots.

Report.—A good exhibit of tin and samples of tin ore.

Group III.

Group III.—Chemistry and Pharmacy, including the Apparatus.

Lunatic Asylum Commissioners of Tasmania, Tasmania.

Essential Oil of Eucalyptus Globulus.

Report.—Commended for a good display of the essential oil of the blue gum tree (*Eucalyptus globulus*), in considerable quantity.

Group IV.

Group IV.—Animal and Vegetable Products, and the Machinery for their Preparation.

C. F. Creswell, Hobart-Town, Tasmania.

Cereals.

Report.—Commended for the fine appearance and good weight of five varieties of wheat and one of oats; also for lucerne and white clover seed, well cleansed and genuine.

W. H. D. Archer, Longford, Tasmania.

Wheat.

Report.—Commended for fine appearance and good weight.

GEORGE KEMP, Upper Bagdad, Tasmania.

White Wheat.

Report.—Commended for fine appearance and good weight.

GROUP V.—FISH AND FISH PRODUCTS, APPARATUS OF FISHING.

COMMISSIONERS OF TASMANIA.

Brown Trout.

Report.—Commended as being a fine specimen, showing the result of the introduction of a new species into Tasmania.

GROUP VI.—TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY.

C. F. CRESWELL, Hobart Town, Tasmania.

Collective Exhibit of Field Seeds, and Seeds of Trees and Shrubs.

Report.—A fine collective exhibit, containing tares, several varieties of peas, beans, various clovers, lucerne, rye-grass, linseed, and rape; also a large and interesting exhibit of great variety of seeds of forest trees, and flowering shrubs native to Tasmania and the Australian Colonies.

GROUP IX.—WOOL AND SILK FABRICS, WITH THE MACHINERY.

J. BROCK, Campania, Tasmania.

Merino Wool.

Report.—Fleece of pure merino wool, of very superior quality and growth.

GEORGE W. KEACH, Chiswick, Ross, Tasmania.

Wool.

Report.—A fleece of four years' old ram, and one of five years' old ewe; wool of good quality and adapted for combing.

DAVID TAYLOR, St. Johnstone's, Tasmania.

Merino Wool.

Report.—Fleeces of pure merino wool in the grease; all of superior quality and merit.

CHARLES HEADLAM, Egleston, Tasmania.

Merino Wool.

Report.—Fleeces of pure merino wool of excellent quality, staple, and fibre.

SAMUEL PAGE, Belle Vue, New Town, Tasmania.

Merino Wool.

Report.—Fleeces of pure merino hot-water washed wool; all of superior quality and excellent growth.

FREDERICK SHAW, Redbanks, Swansea, Tasmania.

Leicester Wool.

Report.—One fleece of Leicester wool, of excellent quality and growth.

WM. H. GIBSON, Fairfield, Snake Banks, Tasmania.

Merino Wool.

Report.—For fleeces of pure merino raw wool, of superior quality and staple.

JOHN TAYLOR, Milford, Campbell Town, Tasmania.

Merino Wool.

Report.—Washed and skirted yearling merino ewe wool, of first-rate quality, adapted for the manufacture of the finest goods.

W. GIBSON & SON, Scone, Perth, Tasmania.

Merino Wool.

Report.—Fleeces of pure merino ram, ewe, and hogget wool, all of excellent quality and of the highest merit.

GEORGE WILSON, Oatlands, Tasmania.

Merino Wool.

Report.—Several fleeces of fine merino wool, of excellent quality, well bred, and of good staple, weighing about eleven and a half pounds each.

JAMES GIBSON, Belle Vue, Cleveland, Tasmania.

Merino Wool.

Report.—Fleeces of pure merino ram, ewe, and lambs' wool, all of excellent quality and growth.

W. H. D. ARCHER, Brickendon, Longford, Tasmania.

Wool.

Report.—Samples of pure merino and lambs' wool, all of excellent quality and growth.

GEORGE TAYLOR, Milford, Campbell Town, Tasmania.

Merino Wool.

Report.—Several very superb fleeces from stud merino ram, valuable for length of fibre and adaptation for the manufacture of the best merinos and cashmeres.

HON. JAMES MACLANACHAN, Ballochmyle, Tasmania.

Wool.

Report.—Fleeces of pure merino rams' wool, in the grease, of excellent growth and quality, weighing from ten to eleven pounds each.

W. S. SHARLAND, Woodbridge, New Norfolk, Tasmania.

Wool.

Report.—Fleeces of pure merino wool, of good quality, fibre, and staple.

JOHN RALSTON, Logan, Evandale, Tasmania.

Wool.

Report.—Several fleeces of pure merino wool, of good quality and growth; also Leicester fleeces of very good length, staple, and quality, highly creditable to the grower.

THOS. PARRAMORE, Beaufort, Ross, Tasmania.

Merino Wool.

Report.—Several fleeces of wool from pure merino ram and ewes, of very superior quality and staple.

Tasmania.

GROUP X.—CLOTHING, FURS, INDIA RUBBER GOODS, ORNAMENTS, AND FANCY ARTICLES. Group X.

J. BIDENCOPE, Hobart Town, Tasmania.

Hats and Caps of Silk and Felt, with Material for Manufacture.

Report.—Felt hats of good quality and finish.

COLLECTIVE EXHIBIT. Collective Exhibit.

GOVERNMENT OF TASMANIA.

Collective Exhibit.

Report.—A creditable display by seventy-seven exhibitors, representing the manufactures, the agricultural products, animal and vegetable products, and the educational system of the colony; also maps and charts illustrating public works and geological formation of the colony.

TRINIDAD. Trinidad.

GROUP I.—MINERALS, MINING AND METALLURGY, INCLUDING THE MACHINERY. Group I.

THOS. A. FINLAYSON, Island of Trinidad, West Indies.

Asphalt.

Report.—Commended for superior quality of asphalt.

GROUP III.—CHEMISTRY AND PHARMACY, INCLUDING THE APPARATUS. Group III.

COLONIAL CO. (LIMITED), Trinidad.

Sugar.

Report.—Commended for the good quality of crystallized sugar from St. Madeleine factory.

GROUP IV.—ANIMAL AND VEGETABLE PRODUCTS, AND THE MACHINERY FOR THEIR PREPARATION. Group IV.

DR. J. G. B. SIEGERT & SONS, Port of Spain, Trinidad.

Angostura Bitters.

Report.—Commended for purity and genuineness of compound.

GROUP VI.—TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY. Group VI.

H. PRESTOE, Government Botanist, Trinidad.

Woods.

Report.—A good collection of woods, well selected and botanically described.

GROUP VIII.—COTTON, LINEN, AND OTHER FABRICS. Group VIII.

HENRY PRESTOE, Government Botanist, Trinidad.

Vegetable Fibres.

Report.—Commended for the interesting and varied collection of fibres of vegetable origin collected and exhibited by him, and for their prospective value as subjects for manufacture.

Trinidad.

Collective Exhibit.

Collective Exhibit.

Government of Island of Trinidad.

Collective Exhibit.

Report.—An interesting display of the natural resources of the island of Trinidad.

VICTORIA.

Victoria.

Group I.

Group I.—Minerals, Mining and Metallurgy, including the Machinery.

J. L. Bleasdale, Melbourne, Victoria, Australia.

Collection of Gems.

Report.—An instructive collection of the precious stones found in the superficial deposits of Victoria.

Acadia Catherine Gold Mining Co., Sandhurst, Victoria, Australia.

Gold Ores.

Report.—Commended for the number and value of specimens exhibited.

R. Brough Smyth, Melbourne, Victoria, Australia.

Geological Maps, Reports, &c.

Report.—A geological map of the Province of Victoria, with various local maps and reports on geology, palæontology, and mining statistics.

Government of Victoria, Australia.

Collection of Rocks and Minerals.

Report.—A large collection of rocks, economic minerals, and organic remains, with a full descriptive catalogue, giving a view of the geology of Victoria.

R. Hodgson, Collingwood, Victoria, Australia.

Antimony, Lead, Tin.

Report.—Commended for the purity of star antimony, pigs of lead, and blocks of tin, all smelted in the colony.

Croaker, Scott, & Co., Melbourne, Victoria, Australia.

Regulus of Antimony.

Report.—Commended for the good quality of the samples of antimony regulus.

Costerfield Gold and Antimony Co., Melbourne, Victoria, Australia.

Sulphide of Antimony, other Ores, and Regulus.

Report.—Commended for the good collection of ore, and the excellence of the metal produced.

Bright Bros. & Co., Melbourne, Victoria, Australia.

Star Antimony in Ingots.

Report.—Commended for good quality.

COMMISSIONERS FOR VICTORIA, Melbourne, Victoria, Australia. Victoria.

Fac-simile of Gold Nuggets found in Victoria. Group I.

Report.—Interesting as specimens of the mineralogy and metallurgy of gold.

GROUP II.—POTTERY, GLASS, ARTIFICIAL STONE, &c. Group II.

G. D. GUTHRIE, Epsom, Sandhurst, Victoria, Australia.

Stoneware.

Report.—Commended for good workmanship and excellent material.

GROUP III.—CHEMISTRY AND PHARMACY, INCLUDING THE APPARATUS. Group III.

COMMISSIONERS FOR VICTORIA, Melbourne, Victoria, Australia.

Chemicals.

Report.—Commended for good quality of chemical products chiefly used in pharmacy.

HOOD & CO., Melbourne, Victoria, Australia.

Essential Oils and Chemicals.

Report.—Commended for the good quality of essential oils distilled from native plants, and of chemical products used in pharmacy.

CHARLES FITT & SONS, Melbourne, Victoria, Australia.

Animal Oils.

Report.—Commended for the good quality of neat's-foot and trotter oil shown, manufactured on a considerable scale from residues of Australian meat preservation.

APOLLO STEARINE CANDLE CO., Melbourne, Victoria, Australia.

Candles.

Report.—Commended for the exhibition of stearine candles and crude paraffine from shale; for good quality of candles, and for the initiation of an industry new to Australia in making paraffine from the shale of that country.

KITCHEN & SONS, Melbourne, Victoria, Australia.

Stearine and Candles manufactured of Stearine.

Report.—Commended for the good quality of candles manufactured of stearine from pressed tallow; and for the importance given the manufacture.

ALEXANDER BORTHWICK, Melbourne, Victoria, Australia.

Paints and Varnishes.

Report.—Commended for the excellence of quality of varnishes, anti-corrosive paints, and anti-fouling composition for ships' bottoms.

JOSEPH BOSISTO, Richmond, Melbourne, Victoria, Australia.

Essential Oil of Eucalyptus, Potash from the Mallee Shrub, and Essential Oil of Mallee Shrub.

Report.—Commended for the production of essential oil of eucalyptus, capable of use in perfumery; for the experiments made for utilizing the mallee shrub and other Australian plants in the production of useful substances, such as gums, oils, and potash.

Victoria.
Group III.

HENRY REED & Co., South Yarra, Victoria, Australia.

Vinegar.

Report.—Commended for the good quality of higher grades of vinegar exhibited.

Group IV.

GROUP IV.—ANIMAL AND VEGETABLE PRODUCTS, AND THE MACHINERY FOR THEIR PREPARATION.

COMMISSIONERS FOR VICTORIA, Australia.

Flour from Winter Wheat.

Report.—Colour good, strength fair; adapted for general consumption, without any special qualities.

JAMES F. MCKENZIE, Melbourne, Victoria, Australia.

Oatmeal, Groats, and Spices.

Report.—Commended for the good quality of the articles and their perfect soundness after so long a sea-voyage. Mustard, mixed spices, and ground cinnamon also of very good quality.

T. B. GUEST & Co., Melbourne, Victoria, Australia.

Fancy Biscuits.

Report.—Commended for excellence and extent of variety.

SMITH & SON, Melbourne, Victoria, Australia.

Fancy and Dessert Biscuit.

Report.—Commended for excellence and extent of variety.

ANGUS POLSON, Moyston, Victoria, Australia.

Cereals.

Report.—Commended for the great weight and very fine appearance of two varieties of wheat, one of oats, and one of barley.

ST. ARNAUD PASTORAL SOCIETY, St. Arnaud, Victoria, Australia.

Cereals.

Report.—Commended for great weight and very fine appearance of wheat, oats, and barley.

THOS. ROSSI, Dry Diggings, Victoria, Australia.

Wheat.

Report.—Commended for fine appearance and good weight.

THOS. O'REILLY, Toolamba, Victoria, Australia.

Wheat.

Report.—Commended for good weight and fine appearance.

JAMES CATLIN, Runnymede, Victoria, Australia.

Wheat.

Report.—Commended for the great weight and fine appearance of two varieties.

JAS. ADAMS, Wahring, Victoria, Australia.

White Tuscan Wheat.

Report.—Commended for fine appearance and great weight.

ARARAT FLOUR MILL CO., Ararat, Victoria, Australia.

Wheat.

Report.—Commended for good appearance and great weight.

JOHN MONCRIEFF, Goulburne River, Victoria, Australia.

Wheat.

Report.—Commended for the good weight and fine appearance of three varieties.

GEORGE SMITH, Ballarat, Victoria, Australia.

Wheat and Rye Grass Seed.

Report.—Commended for good weight and very fine appearance of wheat; also for good exhibit of rye grass seed.

J. MCNAB, Tabilk, Victoria, Australia.

Wheat.

Report.—Commended for good weight and appearance.

ANDREW O'KEEFE, Adelaidevale, Victoria, Australia.

Wheat.

Report.—Commended for the great weight and very fine appearance of two varieties.

T. S. WRIGHT, Rochester, Victoria, Australia.

Wheat.

Report.—Commended for great weight and very fine appearance.

EDWARD BUCKLY, Newbridge, Victoria, Australia.

Wheat and Oats.

Report.—Commended for the great weight and beautiful appearance of four samples of red straw wheat, said to have grown on different soils; also for very fine oats.

JAMES SCOTT, Indigo, Victoria, Australia.

Wheat.

Report.—Commended for fine appearance and good weight.

JOSEPH MYRING, Campbell Creek, Victoria, Australia.

Barley.

Report.—Commended for great weight and fine appearance.

ANDREW GILMOUR, Colvinsky, Victoria, Australia.

Oats.

Report.—Commended for the fine appearance and great weight of three varieties.

STRINGER & Co., Melbourne, Victoria, Australia.

Sauces, Pickles, and Curry Powders.

Report.—A good collection of mixed pickles, sauces, catsups, curry powder, &c., that recommends itself by its great variety, as well as by the good flavour of the different articles and the care with which they are put up.

EDWARD ZORN, Oakleigh, Victoria, Australia.

Tomato Sauce and Oakleigh Sauce.

Report.—The tomato sauce is of a beautiful colour, like the fresh fruit, and both it and the Oakleigh sauce have an excellent taste.

GEO. LYON, Beechworth, Victoria, Australia.

Sauce (Bogong Sauce).

Report.—Commended for the good, wholesome flavour of the Bogong sauce and for careful preparation.

HENRY COMFORT, Cheltenham, Victoria, Australia.

Tomato Sauce.

Report.—The tomato sauce is very carefully prepared, of a good colour and excellent taste.

S. P. HOGG & Co., Melbourne, Victoria, Australia.

Curry Powder.

Report.—Commended for the following reasons: the delicious taste of the curry powder; the care with which it is put up.

WESTERN MEAT PRESERVING CO. (LIMITED), Colac, Victoria, Australia.

Preserved Meats and Soups.

Report.—Commended for the following reasons:

1. Careful preservation.
2. Variety.
3. Freshness of taste.

MELBOURNE PRESERVING CO., Maribyrnong, Salt Water River, Victoria, Australia.

Preserved Meats and Soups in Cans.

Report.—Commended for the following reasons:

1. Great care in cooking and packing.
2. Excellent flavour.
3. Freshness of taste and excellent preservation.
4. Great variety.

HENRY REED & Co., South Yarra, Victoria, Australia.

Raspberry Vinegar and Lime-juice Cordial.

Report.—Commended for strength of natural flavour, and purity of material used, as well as good quality.

WARRENHEIP DISTILLING CO., Ballarat, Victoria, Australia.

Spirits.

Report.—Two samples of whisky one and two years old; very good distillation in Scotch style. Two samples of gin, also very good distillation; and one of spirits of wine, of fair quality.

JOHN TREACY & Co., Geelong, Victoria, Australia.

Ale and Stout in Bottles.

Report.—The ale is sound and good for a light ale, and the porter of very good quality and well bottled.

EDWARD LATHAM, Carlton, Victoria, Australia.

Ale and Porter.

Report.—Several samples of ale, well brewed and in good condition, also of fine aroma. The porter is also of good quality.

P. J. MARTIN, Melbourne, Victoria, Australia.

Ale.

Report.—This ale is brewed from Victorian malt and Tasmanian hops; is very fine, exceedingly well brewed, and of delicate flavour.

HENRY REED & Co., South Yarra, Victoria, Australia.

Lime-juice Cordial.

Report.—The lime-juice cordial is excellent, and the taste and freshness of the fruit are wonderfully well preserved.

CHARLES BRASCHE, Sunbury, Melbourne, Victoria, Australia.

Australian Wines.

Report.—Commended for very good style and elegance.

CHARLES MAPLESTONE, Heidelberg, Melbourne, Victoria, Australia.

Australian Wines.

Report.—Commended for the superior quality of his "Riesling," which showed in a pleasant way the flavour of this grape.

F. EGLI, Tabilk, Seymour, Victoria, Australia.

Australian Wines.

Report.—Commended for the good quality of his wine, which showed careful treatment and good culture.

FREDERICK GRASSE, Strathfieldsaye, Victoria, Australia.

Australian Wines.

Report.—Commended for good quality and style.

ST. HUBERT'S VINEYARD Co., Yering, Melbourne, Victoria, Australia.

Australian Wines.

Report.—Commended for the pleasant style of the "Riesling" produce.

J. S. JOHNSTON, Sunbury, Melbourne, Victoria, Australia.

Australian Wines.

Report.—Commended for good quality.

BEAR & FORD, Tabilk, Seymour, Victoria, Australia.

Australian Wines.

Report.—The wine was found clear and palatable, of a fine bouquet.

Victoria.

Group IV.

OTTO JUNG, Castlemaine, Victoria, Australia.

Wines.

Report.—A fine, full-bodied Hermitage, 1871, of good condition.

JOSEPH BEST, Great Western, Victoria, Australia.

Wines.

Report.—The Hermitage, 1871, was found full in body and elegant in style.

FRANZ SCHMITT, Berwick, Melbourne, Victoria, Australia.

Australian Wines.

Report.—Commended for the very superior quality of the Riesling.

CARL POHL, Strathfieldsaye, Sandhurst, Victoria, Australia.

Australian Wines.

Report.—Commended for good condition and quality.

FABRIZZIO CRIPPA, Hepburn, Victoria, Australia.

Wines.

Report.—Commended for the fine flavour, colour, and taste of his Hermitage, 1871.

G. S. SMITH, Wahgungah, Melbourne, Victoria, Australia.

Australian Wines.

Report.—Commended for the elegance of a rich dessert wine.

SWALLOW & ARIELL, Victoria, Australia.

Biscuits.

Report.—Commended for variety and good quality.

T. K. BENNETT, Victoria, Australia.

Preserved Meats.

Report.—Commended for good quality and flavour; well preserved and well canned.

Group V.

GROUP V.—FISH AND FISH PRODUCTS, APPARATUS OF FISHING, &c.

F. ST. JOHN, Melbourne, Victoria, Australia.

Specimens of prepared Fish.

Report.—Commended as well prepared and in good state of preservation.

Group VI.

GROUP VI.—TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY.

DEPARTMENT OF LANDS AND AGRICULTURE, Melbourne, Victoria, Australia.

Woods.

Report.—A large and excellent exhibit of woods, well arranged, and having botanical name and description on each specimen.

Victoria.

DIRECTOR OF THE BOTANIC GARDENS at Melbourne, Victoria, Australia.

Group VI.

Carpological Collection, Woods, Timbers, Gums, and Resins.

Report.—Commended for the fulness of the exhibit, the large number and variety of the specimens, and the scientific and commercial interest of the collection.

DIRECTOR OF THE BOTANIC GARDENS of Melbourne, Victoria, Australia.

Collective Exhibit of Gums, Resins, Vegetable Fat, and Caoutchouc.

Report.—Commended for the interest and fulness of the exhibit, which is accompanied with a report with the common and botanic names of the species producing the articles.

Group VII.

GROUP VII.—FURNITURE, UPHOLSTERY, WOODENWARE, BASKETS.

LOUIS MUSCHIALLI, Melbourne, Victoria, Australia.

Pier Glass and Console Table.

Report.—Commended for originality of design and good workmanship.

DRAPER & SONS, Melbourne, Victoria, Australia.

Earth Closets.

Report.—Commended for ingenuity and simplicity of design, combined with utility and durability.

JAMES MCEWAN, Melbourne, Victoria, Australia.

Sideboard.

Report.—Commended for good design and excellent workmanship.

ALCOCK & Co., Melbourne, Victoria, Australia.

Billiard Table.

Report.—Commended for good workmanship.

Group VIII.

GROUP VIII.—COTTON, LINEN, AND OTHER FABRICS.

THOMAS LONGMIRE, Kooroocheang, Smeaton, Victoria, Australia.

Flax Stalks, Seeds, and Jute.

Report.—Very fair specimens, of good quality.

THOMAS MCPHERSON & Co., Melbourne, Victoria, Australia.

Jute.

Report.—Long and soft jute, strong in fibre and of very good quality.

COMMISSIONERS FOR VICTORIA, Melbourne, Victoria, Australia.

Vegetable Fibres.

Report.—Commended for the very large and valuable collection of vegetable fibres exhibited; destined to be of great importance in the future development of manufacturing industry.

Victoria.

Group VIII.

BOTANICAL GARDENS, Melbourne, Victoria, Australia.

Fibres of different Trees and Plants.

Report.—Commended for discovery, adaptation for trade purposes, perseverance in preparation thereof, general utility, of following fibres; flume tree, bottle tree, lantern flower, Chinese grass, cloth plant, tree nettle; large assortment, of great variety; good coloured jute.

Group IX.

GROUP IX.—WOOL AND SILK FABRICS, WITH THE MACHINERY.

MRS. BLADEN NEILL, Melbourne, Victoria, Australia.

Raw Silk and Cocoons.

Report.—A good exhibit of raw silk and cocoons, highly creditable from the fact that this branch of industry has only lately been introduced. The raw silk, particularly from the reproduction of Japanese and Grenoble cocoons, has great elasticity.

MRS. ANN TIMBRELL, Collingwood, Victoria, Australia.

Raw-silk Cocoons.

Report.—A good display of raw-silk cocoons of a variety of races, very firm and of good quality.

COMMISSIONERS FOR VICTORIA, Melbourne, Victoria, Australia.

Raw Wool.

Report.—Washed lambs' wool, greasy wool, and Victoria merino; all well selected and of excellent growth and quality.

JOHN LANG CURRIE, Larra, Derimallum, Victoria, Australia.

Wool.

Report.—Three fleeces of lambs' and merino wool of superior quality and in good condition. The lambs' wool is specially good.

THOMAS F. CUMMING, Stony Point, Victoria, Australia.

Merino Wool.

Report.—Sample of very superior combing greasy merino wool, of excellent quality and growth.

JOHN WILSON, Lismore, Victoria, Australia.

Wool.

Report.—Three fleeces of greasy merino lambs', ewes', and wethers' wool, of good quality and growth, adapted both for combing and clothing purposes.

W. & N. G. ELDER, Elder, Rookwood, Victoria, Australia.

Wool.

Report.—An excellent exhibit of merino lambs', ewes', and wether wool, of very superior quality and growth.

R. GOLDSBROUGH & Co., Melbourne, Victoria, Australia.

Wool.

Report.—A very considerable variety of greasy and washed merino wool, most of which is of very superior quality and growth, and adapted for both clothing and combing purposes.

GEORGE ARNOLD & Co., Melbourne, Victoria, Australia.

Wool.

Report.—Five cases of wool, containing thirty fleeces of washed and greasy merino; also, Lincoln, Leicester, and cross-bred. The merinos are excellent in every respect, and the Leicester crosses are of considerable merit.

TIMMS BROTHERS, Mount Hesse, Victoria, Australia.

Wool.

Report.—Samples of ewe and wether merinos, hot-water washed, of very superior quality and fibre.

HASTINGS CUNNINGHAM & Co., Melbourne, Victoria, Australia.

Wool.

Report.—A most complete assortment of fine washed combing merino wool; also greasy rams' wool, and cross-bred and Lincoln ewe fleeces. The merino wool is excellent in every respect, and reflects great credit on the growers.

ALEXANDER ARMSTRONG, Warramtine, Victoria, Australia.

Wool.

Report.—A very creditable exhibit of washed and greasy merino wool, of excellent quality and growth.

THOMAS RUSSELL, Barunah Plains, Victoria, Australia.

Wool.

Report.—Hot-water washed wool, of excellent quality and high merit.

VICTORIAN WOOLLEN CLOTH Co., Victoria, Australia.

Woollens.

Report.—Shawls, tweeds, and broadcloths, made of pure wool and of honest and substantial manufacture; very creditable for a new country.

GEO. SYNNOT & Co., Geelong, Victoria, Australia.

Lincoln Wool.

Report.—Samples of well-grown Lincoln wool, of good staple and rich fibre.

SIR SAMUEL WILSON, Oakleigh Hall, Victoria, Australia.

Merino Wool.

Report.—Five bales of very fine merino wool, both ewes' and hoggets', remarkable for fineness of fibre and length of staple; admirably adapted for the manufacture of the finest cloths and cassimeres.

BALLARAT WOOLLEN Co., Ballarat, Victoria, Australia.

Tweeds, Shawls, and Flannels.

Report.—Tweeds, shawls, and flannels of honest and substantial manufacture, at moderate cost and good for general use.

ALEXANDER GRAY & Co., Albion Woollen Mills, Geelong, Victoria, Australia.

Tweeds and Shawls.

Report.—All wool tweeds, in a handsome assortment of shawls and patterns, and of honest and substantial manufacture.

Victoria.

Group X.

Group X.—Clothing, Furs, India-rubber Goods, Ornaments and Fancy Articles.

Madame F. de Richelieu, Windsor, Victoria, Australia.

Flowers made from Fish Scales.

Report.—Flowers made from fish scales, very nicely executed, and hand-made. Commended for artistical workmanship and skill.

Ford Brothers, Melbourne, Victoria, Australia.

Pith Sunshades for Horses.

Report.—The pith sunshades for horses are of a very useful, original, and practical form to protect horses from the heat of the sun. Commended for the originality and utility of this improvement.

Commissioners for Victoria, Melbourne, Victoria, Australia.

Furs.

Report.—Plain rugs made from skins of native animals, viz., the bear or sloth, opossum, and cat; also fancy rugs of different kinds of skins, in tasteful designs, well made, and cheap.

Group XII.

Group XII.—Leather and Manufactures of Leather.

John Clark & Sons, Melbourne, Victoria, Australia.

Sole and Harness Leather and Basils.

Report.—Commended for good skill and workmanship in the manufacture of the sole leather tanned with wattle bark.

Wallis & Co., Melbourne, Victoria, Australia.

Morocco and Sheep Skins in a variety of Colours and Styles of Finish, for Shoes, Bookbinding, and Furniture.

Report.—Commended for skill in tanning, colouring, and finishing; being notable for evenness and permanence of colour and evenness and regularity of the grain. An exhibit evincing skilled workmanship.

Bearley Brothers, Geelong, Victoria, Australia.

Sole Leather tanned with Wattle Bark.

Report.—Commended for good skill and workmanship in the preparation of the hide and manufacture of the leather; notable for the perfection of finish and solidity of the leather.

John Rosier, Melbourne, Victoria, Australia.

Fine Hand-made Boots and Shoes for Custom Trade.

Report.—This exhibit consists of gentlemen's fine calf and patent leather boots and gaiters, and ladies' fine shoes, and is notable for skilful workmanship, prime material, excellent taste and styles, and correct proportions.

Group XIII.

Group XIII.—Paper, Stationery, Printing, and Bookmaking.

Samuel Ramsden, Melbourne, Victoria, Australia.

Paper.

Report.—News and wrapping paper, of good quality, made of native fibres.

GROUP XIV.—APPARATUS FOR HEATING, LIGHTING, VENTILATION, WATER SUPPLY, DRAINAGE, &C.

GEORGE PEPPER, Windsor, Victoria, Australia.

Ceiling and Wall Ventilators.

Report.—They are well adapted for aiding, in their respective forms, in promoting ventilation.

EDWARD MURPHY, Melbourne, Victoria, Australia.

Centre Flowers and Ventilators.

Report.—They are well adapted for aiding in promoting ventilation, in their respective forms.

JOHN MCILWRAITH, Melbourne, Victoria, Australia.

Tinned Composition Gas-pipe.

Report.—It is of excellent construction (hydraulic pressed) and of apparent durability.

JOHN DANKS, Melbourne, Victoria, Australia.

Steam Valves, Cocks, Valves, Suet Lubricators, Injectors, Sluice Valves, General Brass Foundry.

Report.—Commended for variety of patterns, purity of metal, and excellent mechanical skill and workmanship.

GROUP XVII.—CARRIAGES, VEHICLES, AND ACCESSORIES.

STEVENSON & ELLIOTT, Melbourne, Victoria, Australia.

Landau.

Report.—Commended for general good work and construction; and had not this carriage been damaged by salt water on the way here, it would have compared not unfavourably with the best work entered for competition.

WADE BOTHWELL, Melbourne, Victoria, Australia.

Harness, Saddles, and Stockmen's Whips.

Report.—Commended as good work and well adapted to the uses for which it is intended.

GROUP XIX.—VESSELS AND APPARATUS OF TRANSPORTATION NOT INCLUDED IN OTHER GROUPS.

DUNCKLEY & MCBRIDE, Melbourne, Victoria, Australia.

Sash and Lathe Lines.

Report.—Superior articles, and almost of indefinite endurance, made from sheep intestines.

GROUP XX.—MOTORS, HYDRAULIC AND PNEUMATIC APPARATUS, &C.

A. LE GRANDE, Melbourne, Victoria, Australia.

Patent Abyssinian Tube Wells, and Pumps, with Boring Apparatus.

Report.—Commended for the interesting exhibit of well-designed tools, tubes, and pumps, intended for the rapid construction and immediate and efficient use of tube wells.

Victoria.

Group XXIV.

Group XXIV.—Medicine, Surgery, and Prothesis.

Joseph Bosisto, Richmond, Melbourne, Victoria, Australia.

Chemical and Pharmaceutical Preparations from the Eucalyptus Globulus.

Report.—Commended for variety and extent of the collection of medicinal preparations, for the capacity and industry shown in developing the indigenous materia medica, and for the scientific benefit arising from the opportunity afforded for accurate experiment upon the medicinal properties of the eucalyptus.

Group XXVI.

Group XXVI.—Architecture and Engineering.

Government of Victoria, Australia.

Maps.

Report.—Commended for the plain manner in which the occupation of the land is shown.

Group XXVII.

Group XXVII.—Plastic and Graphic Art.

Charles Somers, of the University of Melbourne, Australia.

Medals in Wax: Models.

Report.—These medals are of good design and well executed.

Group XXVIII.

Group XXVIII.—Education and Science.

John Ferres, Government Printer, Melbourne, Victoria, Australia.

Reports, Statistics, and Victorian Newspapers.

Report.—Commended for good printing of useful and important publications.

Victorian Asylum and School for the Blind, Melbourne, Victoria, Australia.

Baskets, Perambulators, and Portmanteaus.

Report.—Commended for very good work and other evidences of good management and instruction on the part of the asylum.

Penal Department, Melbourne, Victoria, Australia.

Leather and other Manufactures, and Documents.

Report.—Commended for the work of the inmates and the satisfactory representations made of the discipline used, and of provision for their instruction, intellectual and moral.

Commissioners of Victoria, Melbourne, Victoria, Australia.

Collection of Books printed in Melbourne.

Report.—Commended for the creditable exhibit of meritorious and valuable colonial publications.

Surveyor-General of Victoria, Melbourne, Victoria, Australia.

Maps of the Colony of Victoria, Plans, &c.

Report.—Commended for the excellence of the maps and plans and accompanying documents.

Victoria.

COMMISSIONERS FOR VICTORIA, Australia.

Books, Medals, and Seals.

Group XXVIII.

Report.—Commended for excellence in printing and binding of the books, and artistic skill in the medals.

COMMISSIONERS FOR VICTORIA, Australia.

Contributions to the Natural History of Victoria.

Report.—Commended for value as scientific contributions to the natural history of Victoria; good in print and binding.

COMMISSIONERS FOR VICTORIA, Australia.

Specimens of Natural History.

Report.—Commended for excellence of preparation and variety of a collection of prepared mammals, birds, and fishes of the colony of Victoria.

ASYLUM FOR THE BLIND, Victoria, Australia.

Industrial Work in Variety.

Report.—Commended for skill in workmanship, and fitness for the purpose intended.

GROUP XXIX.—HORTICULTURE.

Group XXIX.

COMMISSIONERS FOR VICTORIA, Australia.

Ferns.

Report.—Large tree-ferns with stems from ten to fifteen feet in height. Fine specimens of their kind.

MRS. GASKELL, Melbourne, Victoria, Australia.

Wax Flowers.

Report.—Commended for faithful reproduction of Victorian flowers and foliage.

GROUP XXXVI.—POMOLOGY.

Group XXXVI.

COMMISSIONERS OF VICTORIA, Victoria, Australia.

Fruit and Fruit Models.

Report.—In the early part of the Exposition they exhibited a collection of nearly one hundred varieties of apples, which they placed on the tables, after a long voyage, in perfect condition; and exhibited models of other fruits which could not be transported, thereby imparting an excellent knowledge of the pomological products of the colony.

COLLECTIVE EXHIBIT.

Collective Exhibit.

GOVERNMENT OF VICTORIA, Australia.

Collective Exhibit.

Report.—Commended for a fine collection of objects illustrating the natural and artificial products of Victoria, as rocks, soils, indigenous and acclimatized animals (stuffed), grains, fruits, vegetables, wool, manufactures of wood, photography, and also a very interesting collection of pomaceous fruits in wax.

INTERNATIONAL RIFLE MATCHES.

COMPETITION I.

INTERNATIONAL SHORT-RANGE MATCH, 200 YARDS, CREEDMOOR, L. I.

GEORGE DISHER, Canada.

COMPETITION II.

INTERNATIONAL MID-RANGE MATCH, 600 YARDS, CREEDMOOR, L. I.

JOSHUA K. MILLNER, Ireland.

COMPETITION III.

INTERNATIONAL LONG-RANGE MATCH, 800, 900, and 1,000 YARDS, CREEDMOOR, L. I., Sept. 13 and 14, 1876.

Irish Rifle Team.

Major ARTHUR BLENNERHASSET LEECH, Captain.	HENRY DYAS.
JOSHUA K. MILLNER.	Lieut. ALEXANDER WARD.
WILLIAM RIGBY.	Lieut. GEORGE FENTON.
EDMUND JOHNSON.	W. G. D. GOFF.
	W. R. JOYNT.

Scottish Rifle Team.

Col. J. H. H. MACDONALD, Captain.	PETER RAE.
WILLIAM THORBURN.	WILLIAM CLARK.
R. MCVITTIE.	THOMAS WHITELAW.
D. FRASER.	MARTIN BOYD.
DR. J. MITCHELL.	

Australian Rifle Team.

Hon. AUGUSTUS MORRIS, Captain, N. S. Wales.	DANIEL GEE, N. S. Wales.
J. J. SLADE, N. S. Wales.	Major J. T. SLEEP, VICTORIA.
J. S. LYNCH, N. S. Wales.	Lieut. T. T. DRAPER, Victoria.
Captain J. MCGARVIE SMITH, N. S. Wales.	Captain B. J. WARDILL, Victoria.
	Captain H. J. KING, Victoria.

Canadian Rifle Team.

Major J. E. O'REILLY, Captain.	Captain JAMES ADAM.
GEORGE DISHER.	Major W. H. COTTON.
WILLIAM CRUIT.	Major J. M. GIBSON.
GEORGE MURISON.	Captain J. J. MASON.
A. BELL.	

INTERNATIONAL ROWING REGATTA.

AMATEURS.

INTERNATIONAL GRADUATES' RACE.

Dublin University Boat Club.

GEO. H. FERGUSON.	CROKER BARRINGTON.
C. B. BARRINGTON.	GEO. A. E. HICKSON.

Won August 30, 1876, "row over" in 10 minutes 39½ seconds. Distance 1½ miles straight-away.

PROFESSIONALS.

FOUR-OARED SHELLS.

Thames Crew, London, England.

W. SPENCER.	JOHN HIGGINS.
H. THOMAS.	T. GREEN.

Won September 6, 1876, on claim of foul. Distance, 3 miles, one turn.

GENERAL REPORTS.

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GENERAL REPORT

ON

GROUP I.

MINERALS, MINING, AND METALLURGY.

JUDGES.

American.

ALEXANDER L. HOLLEY, New York City.
T. STERRY HUNT, Boston, Mass.
J. M. SAFFORD, Nashville, Tenn.
S. B. AXTELL, Santa Fé, New Mexico.
JOHN FRITZ, Bethlehem, Pa.
AUSTIN SAVAGE, Boise City, Idaho.
W. S. KEYES, Eureka, Nevada.
FREDERICK PRIME, JR., Easton, Pa.
MATTHEW ADDY, Cincinnati, Ohio.
G. C. BROADHEAD, Pleasant Hill, Missouri.

Foreign.

ISAAC LOWTHIAN BELL, M.P. (President), Great Britain.
ERNST F. ALTHANS, Germany.
LOUIS SIMONIN, France.
FERDINAND VALTON, France.
RICHARD AKERMAN, Sweden.
ACHILLE JOTTRAND, Belgium.
L. NICHOLSKY, Russia.
NICOLAS JOSSA, Russia.
THEODOR KJERULF, Norway.
DANIEL DE CORTAZAR, Spain.
MARIANO BARCENA, Mexico.

The following named Judges were temporarily assigned from other groups to assist in the examination of the classes attached to their respective names.

QUINCY A. GILLMORE.—103.
J. S. NEWBERRY.—102.
OTTO MARTIN TORELL.—121.
HENRY WURTZ.—104.

GENERAL REPORT.

MINERALS, MINING, AND METALLURGY.

BITUMEN, ASPHALTUM, PETROLEUM, AND OTHER HYDROCARBONACEOUS SUBSTANCES, EXCEPTING COAL.—By G. C. Broadhead.

Far back in the remote uncertainty of time we find that, in building the Tower of Babel, "slime had they for mortar;" that the ark of Noah was coated within and without with pitch; and we are further told in sacred writ, that the mother of Moses "took for him an ark of bulrushes, and daubed it with slime and with pitch." In the latter instance the pitch was undoubtedly bitumen; in the others, we infer that bitumen was also used, and there is no doubt of its being used in the construction of the Tower of Babel. Herodotus (in *Clio*) informs us that the walls of Babylon were of brick, laid in bitumen. It was heated and used as a cement in the place of mortar; and he also says that they mixed it with the tops of reeds, and it was placed between every thirtieth course of bricks. In the main, his statements have been confirmed by later travellers. Some travellers state that they have found bitumen used in every seventh or eighth course, and even, at one place, it was found between every two courses of bricks. Two kinds of bricks appear to have been used at Babylon, one fire-baked, and the other sun-baked. Some were deposited in lime and sand, or only in clay, others in bitumen.

Bricks from Hillah, with bitumen still adhering to one side, were examined by Parkinson, and the bitumen was found to be still combustible, and would burn when brought into the flame of a candle, yielding a strong bituminous odour. The village of Hillah, or Hellah, is said to occupy the site of the ancient Tower of Babel, and the city of Babylon must have been on or near the present site of Hillah, which is known to have been built of the bricks of the ancient city, and even may have been built upon the very site of ancient Babylon. The bricks examined by Parkinson must, therefore, have been at least 3,500, or, perhaps, even over 4,000 years old.

Bitumen flows out of the ground at Babylon. It is also dug up in Syria; but that used at Babylon was obtained at Hit, or It, or on the river Is, of Herodotus, eight days' journey above Babylon. Bitumen was also much used in building at other places. The wall of Medea, between the Euphrates and Tigris, was built of burnt brick laid in bitumen. We are also informed that the Persians would dip their arrows in pitch, light them, and shoot them upon the roofs of their enemies.

The Dead Sea, or Lake Asphaltites, is mentioned by most of the ancient writers as being very bituminous, and Diodorus states that near its middle a mass of bitumen would rise up every year and float off, appearing in the distance like an island. This was gathered by the neighbouring people, who carried it to Egypt, and there sold it to the Egyptians, who used it in embalming their dead. In modern times, the Arabs procure this bitumen from the shores of the Dead Sea, and sell it at distant places.

Bitumen is spoken of by some of the ancient writers as pissasphaltum, and at Agrigentum it was burned in lamps in place of oil, and called Sicilian oil.

PETROLEUM—ITS EARLY HISTORY.

Mr. William Buck, Curator of Records, Pennsylvania Historical Society, in an interesting article read before the Society March 13, 1876, states, that "the early French missionaries knew of its existence as early as 1627;" and Charlevoix mentions that, "in 1642, the Jesuits found near Lake Erie a thick, oily, stagnant water, which on application of fire would burn like brandy." Messrs. Dollier and Gallinee, missionaries of the order of St. Sulspice, prepared a map of the country in 1670, on which there is marked *Fontaine de Bitumè*, about where is now the town of Cuba, Alleghany County, New York. Charlevoix, who travelled through this country in 1721, mentions this water, which resembled oil, and had a taste of iron. He also names another fountain containing similar water, used by the savages to appease all manner of pains. Sir William Johnson, who visited this region in 1767, mentions the fact of oil being upon the water, and *Spofford's Gazette*, May 1822, mentions the

Seneca Oil-spring, at Cuba, New York. This spring is on a reservation of one mile square belonging to the Seneca Indians, and the oil has been long known as Seneca oil. The earliest mention of petroleum in Pennsylvania was by Charlevoix, who obtained his information from De Joncaire, in 1721. Fort Duquesne was built in 1754; the commandant soon after, in writing to Montcalm, speaks of observing astonishing wonders about three miles above Fort Venango, where he witnessed a religious ceremony of the Senecas. The tribe appeared very solemn; the great chief recited the conquests and heroism of his ancestors; the surface of the stream was observed to be covered with a thick scum, which at once burst into a complete conflagration. The oil had been gathered and lighted with a torch. At sight of the flames the Indians gave a triumphant shout. Lewis Evans, a surveyor employed by the proprietary of Pennsylvania to take geographical observations in 1755, published a map which has "Petroleum" marked thereon, near the mouth of the present Oil Creek, on the Alleghany River. David Zeisberger, a Moravian missionary, who visited the country of the Alleghany River in 1767, speaking of the oil springs, says that "the Indians would dip off the surface-oil, then "stir the well, and when the water has settled, fill their kettles and purify "the oil by boiling." He informs us that it was used by the Indians for toothache, headache, swellings, rheumatism, and sprains, was of a brown colour, and could be used in lamps, and that it burnt well. General Benjamin Lincoln, in 1783, mentions the oil-springs on Oil Creek, Pennsylvania, and says that the soldiers bathed their joints with it, and it afforded relief and freed them from rheumatic complaints; also, that water impregnated with it operated as a gentle purge. The proprietors of the *Columbian Magazine*, in 1787, published a map of Pennsylvania, on which Petroleum was marked near the confluence of Oil Creek and the Alleghany. Since that time there have been frequent mentions of Oil Creek and the oil of this vicinity. Gideon C. Forsyth, in 1808, first mentions the occurrence of Seneca oil in Ohio, and Dr. S. P. Hildreth, in 1809, mentions its occurrence in the Muskingum Valley. General Lincoln, in 1783, speaks of a burning spring in Western Virginia, near which certain hunters had once camped, who, taking a brand to light them to the spring, a few coals were dropped upon the waters, and in a moment the water was in a flame, so that they could roast their meat as well as upon a hot fire. Bituminous and burning springs were also mentioned by Thomas Jefferson and others as occurring on the Great Kanawha. In Kentucky, near Scottsville, in early days, an oil (petroleum) was collected from springs and used for lighting purposes. The *Pittsburgh Gazette*, in 1828, suggested that the city be lighted with petroleum.

On Oil Creek, Pennsylvania, there are found old pits cribbed in with timber, in which trees of several centuries' growth are found growing, evidence of the ancient use of the oil. For many years the entire supply of naphtha was obtained from the surface of these oil-springs, and as late as 1859 Seneca oil was obtained in this way.

The area over which petroleum has been found in the United States extends parallel with the Appalachians, from New York to Tennessee, including an area of 3115 square miles, of which only 39½ miles have produced oil in Pennsylvania. The best known and most prolific oil-springs have been found on Oil Creek, Venango County, Pennsylvania; and here, in 1859, were the first borings for oil. At 71 feet the first crevice was reached, and at 200 feet the second sandstone was passed through. In 1861, at 400 feet depth, the third sandstone was passed through, yielding oil. The Phillips well at that time flowed 3,000 barrels of oil per day, and soon after the Empire had the same flow.*

Salt was the precursor of the discovery of most of the oil-wells. Numerous wells were sunk on Oil Creek and vicinity, and the yield of oil became very great. The consumption was not equal to the supply, and oil sold at one time for 10 cents per barrel. In 1861 it sold at 25 cents per barrel. In 1864 the production had declined to 4,000 barrels per day, and the highest price paid was $14 per barrel* Prof. J. P. Lesley, of Philadelphia, has (1874) published an oil-map, on which the following named oil regions are marked: The extreme northern, in Kent, Bothwell, and Lambton Counties, Canada. Next, commencing in Cattaraugus County, New York, extending through McKean, Warren, Venango, Butler, Lawrence, Alleghany, Beaver, Pennsylvania, and

* Second Geological Survey of Pennsylvania.

terminating in Columbiana, Jefferson, and Hancock Counties, Ohio. A little farther south, an area includes portions of Noble and Washington Counties, Ohio, with Wood, Pleasants, and Ritchie Counties, Virginia. Another area includes portions of Perry, Athens and Meigs Counties, Ohio. Then, at a long distance south-west, we encounter an oil district, including portions of Allen, Barren, Wayne, Clinton, Adair, Cumberland, and Munroe Counties, Kentucky, and Overton County, Tennessee.

Geology of the Petroleum of the United States and Canada.

We learn from the Canada Geological Report for 1863 that in Canada hydrocarbonaceous matters, probably derived from organic remains, are found from the base of the Palæozoic rocks up, and in many instances it assumes the form of bitumen. Its presence is evident in the limestone and dolomites of the Quebec group and Trenton group, and in most of the Palæozoic rocks. At Pakenham the large orthoceratites of the Trenton limestone sometimes hold several ounces of bitumen in their cavities, and at Montmorenci petroleum exudes in drops from the corals of the Birds-eye limestone; but it is more abundant in the higher formations. The dolomites of the Niagara group in the western basin are more or less butuminous, and in parts of Western New York the limestones are so bituminous that when heated the bitumen is seen to exude from them. Those of the Coniferous are still more bituminous. Many fossils, chiefly of the genus *Heliophyllum*, are surrounded and their cells filled with bitumen. In some localities the bitumen is solid, and assumes the form of asphaltum or mineral pitch. According to Prof. Hall mineral oil is found in the septaria of the higher Devonian beds, and also in the overlying sandstone of the Portage and Chemung group. The oil-wells of Pennsylvania and Ohio are extended into the sandstones, but it is even probable that the oil may originate in the Coniferous below. Prof. Newberry thinks the oil of Ohio and Kentucky is derived from Huron shales (Portage) at the top of the Devonian, and that some of the Pennsylvania oil-wells derive their supply from the same horizon. The wells of Western Canada, according to the Canadian geologists, issue from the Coniferous formation. At Enniskillen the borings extend 200 to 300 feet in overlying Chemung and Hamilton shales, which have also 40 to 60 feet of clay and gravel upon them. The neighbouring country here is generally level, and near Petrolia the overlying clay has a nearly uniform depth of 100 feet, beneath which the borings penetrate an average thickness of 380 feet of interstratified blue clay, dolomite, shales and marls of Hamilton and Chemung to the oil-producing stratum. The theory (*Canada Geological Report* 1863) is that the oil originates in limestones, and is retained in a reservoir formed of the overlying sandstone. The petroleum of Athabasca and the North-west Territory occurs in Devonian shales and in large quantities. We learn from the *Pennsylvania Geological Report*, 1874, that on Oil Creek the chief oil-producing rock is a third sandrock below the surface; and, quoting from this report, "an oil-producing spot in the "Pennsylvania regions is an area overlying from 500 to 1,500 feet, a bed of "porous conglomerate from 3 to 75 feet in thickness, the thickest part of the "rock giving the best well, and this thickness is generally found in the centre of "the area, the rock tapering to the edges." We also learn, from the same report, that this is the third sandrock, and that it is not always continuous, but that there do exist detached beds of lens-shaped masses of third sandrock. This sandstone has been passed through at its greatest known depth, at 1976 feet, and appeared to be a white pebble conglomerate containing some green oil. In the same well (Jonathan Watson's) the next highest sandrock was at 1507 feet, and was considered the true third sandrock. Prof. Lesley (in *Geological Report*, 1874) says that the Pennsylvania oils are not entirely confined to three oil-sands, but extend through at least 3,000 feat of measures. There are three chief oil sandrocks, all below the carboniferous strata. Some of the flowing wells have penetrated to these lower sandrocks. Prof. Lesley also says that the Canada oil-bearing rocks pass under Lake Erie, and are far below the Pennsylvania oil-sands of the Alleghany River country. The surface rocks of the oil-wells of West Virginia are sunk in carboniferous strata, but some of the oil is probably from below. The black slates (Huron) of the upper Devonian of Ohio and Kentucky, according to Dr Newberry, abound in hydrocarbonaceous matter, and are undoubtedly the source of the oil supply.

Statistics of Petroleum.

In Canada there are four areas in which natural oil-springs are found, two in Enniskillen, a third in Mosa and Oxford Townships, and a fourth in Tilsonburgh. At the former, wells have been sunk with great success. Near to Oil Creek, in Enniskillen, the thickened oil forms deposits known as gum-beds of viscid, tarry consistency, and covering 2 or 3 acres, of 2 inches to 2 feet in thickness. At Petrolia a bed of solid asphaltum, 2 to 4 inches thick, was found at 10 feet depth in the clay, and sometimes hardened bitumen is found in cavities of the rock. At Enniskillen, the larger supply has been obtained from the deeper wells, and from some petroleum has risen above the surface of the earth. A well 200 feet deep yielded 2,000 barrels in 24 hours. Both oil and water flow out, and in some of the deeper it is saline. The oil-area at Enniskillen covers about 4 square miles. The total oil-producing area of Petrolia and Enniskillen is 11 square miles. From the Catalogue of Canada Minerals, 1876, arranged for the Philadelphia Exhibition, we learn that the borings in Enniskillen average 480 feet. At first the oil flowed spontaneously, but now the wells require pumping. There are at present 300 wells capable of producing petroleum, but only 200 in operation, with between 200 and 300 steam-engines used for pumping and boring. A small proportion of the oil is distilled at Petrolia, but the greater part is refined at London, 50 miles east. At this place are 15 refineries, with a total capacity of 12,000 to 15,000 barrels per week.

The principal oil-works here are the Atlantic Petroleum Works, with Waterman Bros., proprietors. These gentlemen had a large and handsome exhibition in the Canada section, Main Building. The following are statistics from the above-named Catalogue of the Canada exhibits:

	Barrels.
The amount of oil shipped from Enniskillen for the year ending January 1863 (of 40 gallons each)	82,814
Quantity refined in Ontario, year ending 30th June 1871	269,395
" " " " 1872	308,100
" " " " 1873	365,052
" " " " 1874	168,807
" " " " 1875 about	210,000

The greater portion has recently been consumed in the Dominion.

We quote the following statistics of production of the Pennsylvania oil region, from the *Geological Report* of H. E. Wrigley, for 1874:

Year.	Production, Barrels.	Average Price per Year per Gallon.	Amount.	Barrels exported, Crude.	Crude Value of Export at Well.
1859	3,200	·31 cents.	$41,664	—	—
1860	650,000	·16 "	4,368,000	—	—
1861	2,113,000	$2·73 per bbl.	5,770,128	27,812	$75,926
1862	3,056,006	1·68 "	5,135,098	272,192	457,282
1863	2,611,359	3·99 "	10,419,322	706,268	2,818,009
1864	2,116,182	9·66 "	20,442,318	796,824	7,697,319
1865	3,497,712	6·57 "	22,979,967	745,138	4,895,556
1866	3,597,527	3·73 "	13,418,775	1,685,761	6,287,888
1867	3,847,306	3·18 "	10,644,433	1,676,300	5,330,634
1868	3,715,741	4·15 "	15,420,325	2,429,498	10,082,416
1869	4,215,000	5·85 "	24,651,754	2,568,713	15,026,971
1870	5,659,000	3·80 "	21,504,200	3,530,068	13,414,258
1871	5,795,000	4·35 "	25,208,250	3,890,326	16,922,918
1872	6,539,103	3·75 "	24,521,636	4,276,110	16,037,475
1873	9,879,455	1·84 "	18,173,197	4,981,441	9,165,851
1874	10,910,303	1·17 "	12,765,054	4,903,970	5,737,644

Total production, 67,707,094 barrels; average price, $3.48; total value of wells, $235,475,120; total amount exported, 32,490,971 barrels; total value at wells of crude oil exported, $113,950,156.

In the Pennsylvania oil region wells were drilled as follows :

Drilled in 1869	991	wells.
„ 1870	1007	„
„ 1871	946	„
„ 1872	1032	„
„ 1873	530	„
„ 1874	433	„
Total wells drilled from 1869 to 1874, inclusive	4939	„

Or, in round numbers, 5000 wells, producing 42,000,000 barrels. The average life of these wells is two and one-half years. Tables published in the *Engineering and Mining Journal* give,—

Product of 1875	Barrels, 8,787,506
„ 1876	„ 5,023,351

and on January 1, 1876, there were 3,314 producing wells.

Other Localities of Petroleum and Bitumen.

We have recent accounts of valuable petroleum-wells in California. Petroleum and bitumen are also found in Asia Minor, Persia, and Hindostan, and some portions of South America.

In New Zealand, petroleum is obtained from Waipawa, Poverty Bay, Province of Auckland, on the West Coast, and Waipu, on the East Coast. It escapes through cracks in Trachyte breccia at Sugar-Loaf Point, Taranaki. Wells have been bored several hundred feet deep, but no steady supply obtained. Oil from this place was on exhibition at Philadelphia, in the New Zealand section.

The distilled oil has a specific gravity of 0·874 to 0·941. It is, therefore, not adapted for kerosene, which has a specific gravity of 0·810 to 0·820. The crude oil of specific gravity 0·872 of 58° Fahrenheit yields when distilled :—

Fine lamp-oil	11·2 per cent.	Specific gravity	·82
Inferior oil	37·75 „	„ „	·858
Lubricating	25·69 „		
Paraffin	16 „		
Bituminous residue	9·36 „		

Oil in Western Missouri.

Bitumen occurs in Western Missouri from Ray to Newton Counties, a distance of 175 miles north and south, and over a width of 25 to 35 miles, the rocks in the southern half being much saturated with it. From Bates County southwardly, and extending westwardly into Kansas, tar-springs are frequent. Although the rocks are often quite black with tar, and drops are seen oozing out and pools of liquid bitumen are sometimes found, still the product is not concentrated in sufficient quantity at any place to pay for the working. Its mere presence has occasioned the sinking of several deep wells with no profitable result. There exist no positive anticlinals nor synclinals in this district as there are in Pennsylvania, hence there is no room for large basins for collection of oil. Its greatest vertical extent in Missouri is 600 feet, it averages about 300, and it lies chiefly in the lower coal measures, although extending nearly to the top of the middle measures. It is also found in the lower Carboniferous limestones. The sandstones very nearly resemble those on exhibition at Philadelphia from Werwohlen, Brunswick, Germany. An analysis of free bitumen from Minersville, Jasper County, gives,—

Bitumen	95·75 per cent.
Ash (pale yellow)	4·25 „

Bitumen, mixed with sand, from Barton County, Missouri, gave,—

Bitumen - - - - - - - - - - 44·74 per cent.
Ash - - - - - - - - - - 55·26 „

Bituminous sandstone from Southwest Missouri may be found with the Missouri Centennial collection; also, bituminous limestone of lower coal measures.

Other Bituminous Rocks.

Certain thinly laminated rocks, ordinarily termed bituminous shales or slates, occur in the Utica slate of the lower Silurian, as well as the Marcellus and Genesee of the Devonian rocks of Canada and New York. It is well known that similar beds are of frequent occurrence in our coal measures in every State where coal is found.

Dr. T. Sterry Hunt has appropriately termed them "pyroschists," and defines them to be "argillaceous rocks containing, in a state of admixture, a "brownish insoluble and infusible hydrocarbonaceous matter, altered to lig-"nite or coal." Some of these strata contain, in the absence of oil-wells, sufficient oil to distil for illuminating purposes. According to Prof. Worthen (*Illinois Geological Report*, vol. vi.) there are 13 bituminous shale-beds in the Illinois coal-field, aggregating 34 feet in thickness. In Missouri our estimate is 21 beds, with an aggregate of 39 feet. This is a thickness of nearly 2,000 feet of coal measures. A few of these blend into a cannel coal,—for instance, certain beds in Johnson County, Missouri, and the Breckenridge coal of Kentucky. From the latter there was formerly distilled a good quality of illuminating oil; in fact, it was quite celebrated, but the discovery of the rich flowing wells of Pennsylvania suspended its production. We present the following analysis of some of the Kentucky pyroschists as determined by the second Kentucky Geological Survey:

No.	County.	Thickness in feet.	Specific Gravity.	Moisture.	Volatile Combinable Matter.	Total Volume.	Coke.	Ash.	Carbon in Coke.	Sulphur.
1	Edmondson - -	—	1·362	0	59·7	—	40·03	26·	—	—
2	Menifee - - -	22	—	2·80	15·2	18	82·	57·7	24·3	—
3	Wolff - - -	—	14·34	1·80	41·4	—	57·3	29·1	28·2	0·84
4	„ - - - -	3+	1·383	1·16	44·58	—	54·26	21·5	32·76	0·53
5	Breathitt - -	3	1·36	1·60	43·2	—	55·2	21·4	33·8	2·549
6	McLean - - -	—	—	1·60	36·4	—	62·	30·64	31·3	—
7	Muhlenburg - -	—	—	3·56	13·68	17·24	82·76	75·94	6·82	—

Specimens noted in the above table were on exhibition in the Kentucky section, Mineral Annex, at the Exhibition. Most of these are from the base of the coal measures. No. 1 is a cannel shale, which burns freely, and is found under a considerable area, and is six feet thick in Butler County. No. 3 is also a cannel shale, which will form a pulverulent coke. No. 4 is also a cannel shale, over three feet in thickness, from Stillwater Creek. No. 6 is from Wright's, on Frozen Creek. No. 7 is a carbonaceous mud. West Virginia, Pennsylvania, Ohio, Indiana, Illinois, Missouri, Iowa, and Kansas abound in similar bituminous shales, but none were on exhibition.

The bituminous shales of Collingwood, Ontario, when distilled, yield from 3 to 4 per cent. of tarry oil, which when rectified affords illuminating and lubricating oil. The available shale-bed is seven feet thick, and its geological position in the Utica slate. Bituminous shales at the Albert mines, the best, yielded 63 gallons per ton and 7,500 feet of gas per ton. They belong to the Carboniferous formation.

New South Wales.

The kerosene shale-beds underlie a surface of 600 square miles. Their geological position is in the upper coal measures.* A section at Hartley Vale Kerosene Co.'s mine, 8 miles east of Bowenfels, gives,—

1. 1 foot 6 inches fire-clay.
2. 1 inch clay band.
3. 3 inches black casing.
4. 4 inches "tops" or impure shale, yielding 40 gallons of crude oil per ton.
5. 6 to 8 inches black shale.
6. ½ to 8 inches band of inferior fuller's earth.
7. 3 inches ferruginous shale.
8. ½ inch to 8 inches wet pipe-clay.
9. 3 feet 2 inches kerosene shale, yielding up to 80 gallons refined oil per ton.
10. 10 inches "bottoms," yielding 60 gallons of crude oil per ton.
11. ½ inch to 1 inch yellow band of fuller's earth.
12. Bluish sandstone, with impression of plants.

The *Glassopteris Browniana* is found in the above bed of kerosene shale. The kerosene shale occurs in even laminæ, is quite hard, and breaks with a regular conchoidal to splintery fracture with a shining surface. It is really a rich cannel shale. The Murrurundi Petroleum Oil Cannel Co. work this shale 130 miles north-west from Newcastle. At this place it is 14 inches thick, resting on nearly 8 feet of coal and clay. The proprietors, R. Towns & Co., of Sydney, had specimens of this on exhibition at Philadelphia. The New South Wales Shale and Oil Co., of Sydney, had on exhibition a block showing the entire thickness of the seam. They undoubtedly possess the richest seam of kerosene shale; its greatest thickness is 5 feet, the middle 3 feet being the richest. They manufacture kerosene, lubricating, and other oils from the mineral. The shale from the Hartley mine is shipped by rail 80 miles to the works near Sydney: it is also exported for gas-making. An important locality is at the foot of Mount York. Hundreds of thousands of dollars are invested in this industry, and the oil is used for illuminating purposes and gas-making, and it is exported to San Francisco, India, China, and other places, but its chief export is to other Australian colonies, and New Zealand. There is a slight import duty, but the Kerosene Co. have possession of the market and control the trade. The shale yields 18,000 cubic feet of 40-candle or 160 gallons of crude oil per ton from a 3 feet 2 inch seam. On page 56 of *Mines and Mineral Statistics of New South Wales* we find the following table of production of crude oil:—

Year.	Tons.	Value.
1865	570	£2,350
1866	2,770	8,154
1867	4,079	15,249
1868	16,952	48,816
1869	7,500	18,750
1870	8,580	27,570
1871	14,700	34,050
1872	11,040	28,700
1873	17,850	50,475
1874	12,100	27,300
Total	Tons 96,141	£261,414

At Wollongong there have also been established extensive works. Some time since specimens of shale from Megalong and Illawarra were sent to Prof. Silliman, who applied to them the term "Wollongonite" under the impression that they came from Wollongong. Oil has been made from this, but it does not yield so much oil as the Hartley shale.

* See *Mines and Mineral Statistics of New South Wales*, p. 131. Sydney, 1875.

Albertite.

This remarkable mineral very much resembles the asphalte of commerce in being black, brittle, and lustrous, with a broad conchoidal fracture; but it is less friable, and its composition is also different, and it differs in fusibility and in its relation to various solvents. The colour of its powder is porcelain-black; lustre resinous and splendent or shining; perfectly opaque, very bitter, odour bituminous; when rubbed it is electric, burns and emits jets of gas in the flame of a spirit-lamp; it does not melt like asphalte, but can be melted in a close tube. Under the microscope it presents no appearance of organic structure, and is free from mineral charcoal or impure coal. Its composition is,—

Water	·4
Volatile combustible matter	57·2
Ash in coke	·27

It is found in Kings, Albert, and Westmorland Counties, New Brunswick, and occurs in the lower Carboniferous coal formation in calcareo-bituminous shales or pyroschists, which contain much bituminous matter; also in many fossil fishes of the genus Palæoniscus, which are remarkably well preserved. [The above description of Albertite we obtain chiefly from Dr. Dawson's admirable work, *Acadian Geology*.] These shales have been much disturbed and contorted, and, quoting from Dr. Dawson, "at the pit the beds dip at "angles of 50° and 60°, and near the bottom of the shaft consist of cal-"careous and ironstone bands and concretions. The Albert mineral occupies "a vein in these beds having an irregular high dip, preserving a general "course of N. 50° E. to N. 65° E., and at one place is as much as 17 feet "wide, thinning to 1 foot. Twelve hundred feet north-east it bends suddenly "northwardly, the course bearing N. 29° E. for 25 feet, then returning to "N. 50° E." The vein has been worked to a depth of 1,162 feet, and occupies a regular fissure formed by an abrupt anticlinal or arching of the shale-beds, appearing to be parallel to them; but its age is not, therefore, contemporaneous, for there are no stigmaria under-clays which might be expected in a stratified coal-bed.

The mineral must have been, at some former time, in a liquid state, and subsequently hardened, for a little is occasionally found in the spaces between the wall-rocks. Albertite, in small quantities, has been found at other localities, some of them 50 miles distant. The original locality at Hillsborough was discovered in 1849.

The chief export has been to the United States, for making oil, and partly for admixture with ordinary bituminous coals in the preparation of illuminating gas. It yields 100 gallons of crude oil to the ton, or 14,500 feet of superior illuminating gas. The royalty paid to the Government up to January 1, 1866, was $8,809·29, and the amount exported for 12 years, from 1863 to 1874, inclusive, 154,800 tons. The yield from the mine is now becoming less, and the probability is that it will be exhausted before many years. Specimens were on exhibition in the Canada section at the Exhibition.

Grahamite.

This is sometimes called Ritchie mineral, and was discovered in Ritchie County, West Virginia. It occurs under circumstances similar to Albertite, and very much resembles it, being used for similar purposes. It occupies a vertical crevice of 4 to 4½ feet in width, occurring in the Barren coal measures above the horizon of the Pittsburgh coal. It has been worked vertically for 300 feet, and horizontally for 3,315 feet. The direction of the vein is 12° N. of West. It was undoubtedly first deposited in a liquid state, subsequently hardening. An analysis, by Prof. Wurtz,* gives,—

Specific gravity	1·145
Carbon	76·45
Hydrogen	7·83
Oxygen	13·146
Ash	2·26

* *American Journal of Science*, Dec. 1873. W. D. Fontaine.

The Ritchie mineral was included in the West Virginia collection at the Exhibition.

Mexico.

In the eastern part of Mexico, north of Vera Cruz, bituminous rocks occur, and some coralline limestones are thoroughly saturated with it. An asphaltum is also found, which Prof. J. P. Kimball likens to Grahamite.

Peru.

At Caxitamba is a small pitch lake, the bitumen from which is found useful in stopping leaks of boats. A mass of bitumen, of the consistency of tar, was on exhibition.

Argentine Republic.

Liquid bitumen occurs here in large quantities, a little of which was exhibited. Kerosene is made from it.

Cuba.

There were several fine exhibits of asphaltum from this island on exhibition in the Spanish section. The bitumen yields 100 to 140 gallons of oil to the ton, and when purified is admirably adapted to lamps. Daddow and Bannan (in *Coal, Iron, and Oil*) say that the chapapote, or asphalte, of Cuba, is mined like coal, occurring in fissures in the rocks; and flowing springs of petroleum are said to still exist in the vicinity, emanating from fissures extending to the underlying metamorphic rocks. The rocks of the whole island seem impregnated with bitumen, and there are numerous petroleum-springs.

Island of Trinidad.

The wonderful Lake of La Braye, according to Parkinson, is 1½ miles in circuit, is hot at the centre, but solid and cold towards the shore. Its borders, for a breadth of three-quarters of a mile, are covered with hardened pitch, on which trees flourish. At Point La Braye the masses of pitch look like black rocks among the foliage, or as black vitrified rocks. The lake is partly surrounded by mangrove swamps, except towards the sea, and, what is remarkable, the lake itself is on higher ground than the neighbouring swamps. Its outer margin is solid asphaltum, but farther inwards the bitumen, of the consistency of thin mortar, is seen flowing, but in time hardens, and this outward flowing gradually encroaches on the harbour. The outer walls can only be cut with an axe, and in appearance resemble an impure cannel coal, but are grayer in colour. On some parts of the surface are seen thin pieces of black, shining asphaltum. According to Gesner the surface of the lake is occupied by small ponds of clear water, in which are found several kinds of beautiful fish. This remarkable lake is said to repose in recent Tertiary beds, Miocene, and probably Lower Pliocene. The odour of the mineral is apparent in the atmosphere, and it is asserted that it can be detected at eight miles distance. The bitumen, according to Gesner, yields by distillation a whole series of hydrocarbon oils, and gives 70 gallons of crude oil per ton of 2,240 lbs. It is much valued for ship-bottoms, and is reported to kill the teredo. Large masses of asphaltum from Trinidad were on exhibition in the British Colonial section.

Germany.

A specimen of asphaltic sandstone from Werwohlen, Brunswick, was exhibited, together with various compositions into which it enters to form a roofing material, for which it is said to be very well adapted, as it does not melt under ordinary sun exposure. For this purpose ⅞ inch of asphalte is laid

on 3½ inches of cement. The sandstone containing the asphalte is said to be of the Tertiary age. It very closely resembles the bituminous sandstone from the coal measures of South-west Missouri.

Spain.

Bituminous rock from Maestu and refined asphaltum from Vitoria were in the Spanish collection, but I could obtain no data regarding them.

Switzerland.

For pavements the asphalte from Val-de-Travers has a world-wide reputation for excellence. It is said not to crack in cold weather, not being affected by changes of the weather, nor does it possess a bad odour.

Parkinson in 1804 stated that on the south side of a mountain, the northern declivity of which terminates in the Valley of Travers, between Travers and Couvet, near to Neuenburg, there are two large pits containing asphaltum, which in 1758 had been worked upwards of 40 years. At the same height on the other hill-side it was also found. At Neuchâtel it occurs impregnating a limestone bed in the Cretaceous formation, and serving as a cement to the rock which is used for buildings. The rock is quite black and strongly impregnated with it. The Neuchâtel limestone at this time (1876) has been worked for 40 years, and is extensively used throughout Europe for paving purposes and for roofing. The principal agency is in London, but the asphaltum is used in all the chief European cities. In London it is better to use it in a pure state. In Paris it is very much used, but is mixed with rock. The Swiss Commissioner at Philadelphia informed me that he had an acre paved with it at Neuchâtel that had been in use for 15 years without repairs. In Switzerland the preparation for roofing is generally (1) flat tiles are laid in mortar on an inclined roof; (2) then pure asphalte is poured on to the depth of an inch; (3) then clean gravel is placed on the asphalte as closely as possible, causing it to present the appearance of a gravel roof or stone pavement. Specimens of Val-de-Travers rock were on exhibition.

Asphaltum is found at other localities in Switzerland.

Ozocerite.

This hydro-carbon, and, in part, native "paraffin," has a general yellow or yellowish brown to dark colour, and is of a waxy appearance, indeed it much resembles beeswax, especially when refined, is soft and easily pressed with the finger nail. Dana gives Hofstadter's analysis of two specimens :*

A. Melting point, 61° C.	- Carbon, 84·94	- Hydrogen, 14·87
B. „ 65° C.	- „ 85·78	- „ 14·29

It is soluble in ether, turpentine, or naphtha. The products are a wax or resin, both of a delicate white and yellow. Candles are made of it, but they have an unpleasant odour. It occurs in a bituminous clay, associated with calciferous beds in the Carpathians; also in sandstone and shale of the Cretaceous formation from 40 to 160 metres from the surface. Ozocerite was exhibited at Philadelphia by Paul Dobel, principal owner of mines at Boryslaw, in Galicia. It is here associated with rock-salt, asphaltum, and fibrous gypsum, the latter penetrated by asphaltum. The annual production of Boryslaw amounts to 15,000,000 kilogrammes, worth 8 to 20 kreutzers per kilogramme, or 4½*d.* to 7*d.* per lb. It is also found at Slanik, Moldavia, Gaming, in Austria, in Transylvania, and at Upshall, in Linlithgowshire; also near Lake Baikal.

Coorongite ;—Elaterite in part, of Dana. Elastic Bitumen or Mineral Caoutchouc.

A small quantity of this rare and curious mineral was on exhibition from South Australia. Elaterite has been considered a carbo-hydrogen, near

* Dana's *Mineralogy*, p. 782.

ozocerite, of which Dana gives carbon 84·3, hydrogen 12·5, the loss probably wholly or in part of oxygen. Coorongite in a condensed form resembles crude india-rubber, occurring generally in sheets varying in thickness from that of coarse brown paper to an inch, these being evidently the result of evaporation on the surface. It is found along the Coorong coast of South Australia for over 100 miles in length and an average breadth of 20 miles. The country is mostly flat, with occasional swamps and some salt lakes. Over this area it may be collected in drops floating on the water of recently sunk wells, or in crevices of the underlying limestones, or in patches of various areas from very small to several acres, of a leathery substance, or else diffused through a diatomaceous earth, forming a black petroleoid matter. Bitumen is also found. Coorongite burns freely with a reddish flame, melting like bitumen, emitting but little odour. It produces an oil, a tar, and a white wax or paraffin, and has been made into a brilliant illuminating kerosene oil, said to be non-explosive and not inflammable under a temperature of 150°. Considerable oil can also be made from the distillation of the soil of the district. Elastic bitumen has also been found in Derbyshire, accompanied with asphaltum; in a coal-mine of Montrelais, a few leagues from Angers, France; also in a coal-mine near South Bury, Massachusetts. Two substances, amber and Kauri gum, although very much differing from the above in their uses, are yet hydro-carbons. I therefore briefly notice them.

Kauri Gum.

(We possess no analysis of this, but it is nearly related to if not equivalent to the ambrite of Dana.)

The *Dammara Australis* (or Dammara pine) is a coniferous tree, common in New Zealand, which also grows in the Molucca Isles and Amboyna. It is very resinous and quite valuable. In New Zealand the gum is found in large quantities in a fossil state, occurring in the Tertiary formation (according to Dr. Hector, the provincial geologist) at depths of from 5 to 100 feet below the surface, and in amorphous masses weighing from 1 to 350 lbs. Dr. Hector is confident that this gum has originated from the Dammara pine. Its colour is grayish-yellow, fracture conchoidal, and of a glassy brightness. At ordinary temperatures it remains solid, but very warm weather causes it to become slightly flexible, and when rubbed it gives out a terebinthine odour. It is much valued for making varnish, being superior as an article for making furniture and implement varnish. It is valued according to colour and purity. At Auckland the clear, cheap article brings $90 per ton, the dark, clean and scraped, $240, and the bold, bright selected, $300 to $350 per ton.

The export from New Zealand in 1874 was 2,600 tons, value $440,000. It is largely exported to various countries, a great deal being brought to the United States. The gum and its various products were exhibited at Philadelphia.

Amber or Succinite.

This is a vegetable resin, altered by fossilization, sometimes inclosing insects which retain their perfect forms and appendages. It burns with a yellow flame, emitting an agreeable odour, and leaves a black, shining carbonaceous residue. It composition is carbon 78·824, hydrogen 10·228, oxygen 10·9; its hardness 2—2·5. (Dana.) Amber is harder than most resins, and is susceptible of a good polish. It is used for necklaces, mouth-pieces for cigars, and for varnish. It was known to the ancients and called ἤλεκτρον, *electrum*, on account of its electrical susceptibility. It was also engraved and used by the ancients for seals. It occurs abundantly on the Prussian coast of the Baltic, occurring from Dantzic to Memel. It is also found on the coast of Denmark and Sweden; also in Galicia, Poland, Moravia, the Urals, Switzerland, near Basle, France, near Paris, near London, in various parts of Asia, and in the green sand of New Jersey. It is chiefly obtained from Prussia, and is not very abundant in other countries. That at the Exhibition was from Königsberg, and was exhibited by Staaten & Becker.

WROUGHT IRON AND STEEL.

By A. L. Holley.

The very large and comprehensive display of wrought iron and steel at the Centennial Exhibition completely illustrated (1) the present development of the manufacture, both technically and territorially, in the United States and in several foreign countries, notably in Sweden; (2) it furnished important data for estimating the state of the art all over the world; (3) it brought into comparison the results of different methods of treatment, and of the same methods of treatment as practised in different countries; (4) it contributed, together with other sources of information which were connected with the Exhibition, much valuable historical matter concerning the iron and steel manufacture; and (5) it indicated the directions of current and probable improvements.

It is proposed in this report to review those exhibits which illustrate the foregoing propositions in any important degree, both for the purpose of bringing together the data from which conclusions may be drawn and for the purpose of putting on record the contributions of individual scientific men, and of proprietors of works, to the development of the manufacture. It is also proposed to briefly discuss these propositions, and to attempt a general statement of the growth and state of the art, and of the more promising efforts towards its improvement.

Sweden.

Among the most conspicuous of the Swedish exhibits was the Sandvik, which comprised every kind of Bessemer raw material and types of every kind of product. There were a soft 5½-ton ingot broken cold and showing a good fracture; a 16 inches by 13 feet hammer bar with a 38-inch piston forged on; and a cranked axle and other large forgings, all of which, being partly finished, showed perfect soundness. There was a tyre which had run nearly 200,000 miles under a 24-ton locomotive, and was still 1⅝ inch thick; there were a number of tyres and axles finished and then distorted, cold, in such a way as to prove remarkable toughness; also a series of bars containing from 0·20 to 1·10 per cent. of carbon, bent and broken so as to illustrate ductility as varied by carbon; also many samples of steels of different tempers welded together; and, finally, a number of fine cutting-tools, such as razors, made direct from the Bessemer vessel. The Fagersta Works exhibited a series of Bessemer ingot and corresponding blooms containing from 0·15 to 1·00 per cent. of carbon in regular gradation; also locomotive crank-shafts and small forgings which were finished to show perfect soundness, and bent cold, back and forth, to prove great toughness. There were boiler-plates severely tested by flanging and otherwise; also gun-barrels in various stages of manufacture and after excessive tests; there were analysed test ingots and slags taken at various stages of the Bessemer operation, and a comprehensive series of bars mechanically tested by Kirkaldy. The Motala Works exhibited a complete assortment of Bessemer and Martin steel, and wrought-iron materials and products; there were many fractures of blooms and bars; also fractures of Bessemer and Martin ingots, which varied by tenths per cent. in carbon from 0·10 to 1·00 per cent. There were axles and tyres distorted cold, plates flanged to difficult shapes and bent fourfold cold, a 6-ton Martin steel crank-axle, and an 8-ton steel armour-plate. The Swedish Ironmasters Association displayed, under the charge of Prof. Akerman, a remarkably complete series of the iron materials of the country, and their characteristic products, which it would be impracticable to enumerate in this paper; the most striking were excellent chilled car wheels, projectiles, and railway crossings, and Bessemer wire ropes, car-springs, and hand-tools. All this was supplemented by a grand geological map, small topographical maps, and drawings of plant. We thus have a complete picture of Swedish iron and steel manufactures, their extent, the qualities of materials, the excellence of products as proved by chemical and mechanical tests, and the high state of the art as illustrated by the scientific character of the tests and of the arrangement, and by the great range of products.

Norway.

The exhibit of Norway was chiefly that of the Catherineholm Works, which consisted principally of wrought-iron bars, of various sizes, knotted cold in a very elaborate and surprising manner to form the rigging of an ancient ship. There were also wrought-iron plates and spikes and some cast-iron projectiles; also pig iron and blooms. The exhibit illustrated a high degree of quality by old processes, but no new processes nor products.

Germany.

The display of Germany, next to that of Sweden, was the most complete and instructive of all the foreign exhibits, the contribution of Krupp being the most conspicuous. This included a complete assortment of materials for all kinds of iron and steel, and specimens of all the ordinary forms of products, such as rolled bars of every grade, tires, axles, and steel castings; also some extraordinary products, such as elaborate Haswell press forgings, flanged plate-steel gun-carriage trails, very large and well rolled, steel and iron boiler-plates, a 13½-ton 3-throw steel crank-shaft forged from a 56-inch 30-ton ingot, and, most remarkable of all, a 16-inch jacketed breach-loading, rifled, steel gun, 26¼ feet long and weighing 56½ tons. This gun was mounted on an elaborate sea-coast carriage, built of iron and steel; and there were other pieces of ordnance and large forgings. Excepting the numerous fractures of bars, and the soundness of the forgings, there was not as great an attempt as by Swedish exhibitors to prove the quality of the products. The Lower Rhine district was further represented by the joint display of ores, pig iron bars, plates, sheets, and other well made products, by five large establishments. The Upper Silesian exhibit was by A. Borsig; it was comprehensive, but remarkable chiefly for large plates, extremely good steel forgings for locomotives, etc., and Haswell press forgings in great variety, many of which would have been deemed complex if they had been castings. The district of Saarbrücken and Lorraine contributed groups of ores, coals, cokes, and pigs, and sections of many rolled shapes, the prominent feature being a collection of well-rolled iron beams, of various patterns, running in length to 48 feet, and in height to 19¾ inches. The Siegerland was represented by a very well arranged and extensive joint exhibit of iron ores and of spiegeleisen. Thus the German exhibit, although not completely illustrating the extent of the manufacture in that country, was on the whole characteristic; it proved that the range of iron and steel products is extensive in the largest degree, and that the art of producing and working heavy homogeneous masses is of the highest order.

Russia.

The Russian exhibits were chiefly materials for wrought iron and Bessemer and Martin steels, and their products in numerous shapes, as made at the Pooteeloff Works, and by Paul Demidoff. There were rails, tires, plates, and axles, some of which were bent and twisted cold to show quality. The Imperial Works of Kama exhibited large and difficult rolled shapes, and some finished trunnion rings and breech parts, of good quality, for large guns. The Russian display thus gave a very fair idea of the state of the manufacture in that country; it indicated large facilities, and that a considerable range of production is already well established.

Belgium.

The Belgian iron and steel display was contributed by a number of manufacturers. The most noteworthy specimens were plates and bars from the Charleroi Works, puddled from the very ordinary pigs of the region, and thoroughly proved by fracture and distortion to be of superior quality; the puddling was done with kryolite, in a Pernot revolving-hearth furnace. The Rigissa Works' sheets of iron and of Bessemer steel were beautifully rolled, and their quality was shown by the vessels stamped from them. The

Angleur Works' Bessemer rails, axles, and tires were well finished, but were not tested. The Providence Iron Company displayed ordinary sections of iron beams, and it proposed to deliver such beams in New York at $40, "f. o. b.," which was then extremely cheap. The same company showed a wrought-iron railway wheel, with a tread to receive the tire rolled on. Valère Mabile exhibited some very beautiful drop forgings, and some complex and heavy forgings for the Chaudron shaft-sinking apparatus. The Belgian display covered a large and characteristic range of products, although it failed to include any from the John Cockerill Works; this is, probably, the third largest iron-works in the world, considering the value of its output, which includes steam-engines and finished machines. The display, however, illustrated Belgium's facilities for making cheap products of the more ordinary kinds and sizes.

France.

The French exhibits were confined chiefly to wrought-iron railway wheels and ferro-manganese. The wheels shown by Lucien Arbel were stamped in dies out of piles resembling finished wheels; those shown by Brunnon Frères were made from similar piles by hydraulic pressure. The excellence, including cheapness as well as quality, of this manufacture, was fairly shown by the Centennial Exhibition to be peculiar to France, just as the Haswell press forgings from solid steel were shown to be peculiarly German. The ferro-manganese exhibit came very appropriately from the Terrenoire Company, who have done more than all other companies combined to cheapen and improve this valuable steel-making compound; they have scientifically pressed the manufacture through the cupola and the reverberatory, and have finally enlarged and cheapened it in the blast-furnace. The exhibit, though small, showed products ranging from 30 per cent. to 75 per cent. of manganese. There was also a creditable ferro-manganese exhibit from the "Works of the Blast-Furnaces of Marseilles." France, however, to a greater extent than any other country, was unrepresented in the range, the quality, and the extent of her iron and steel manufactures. The armour-plates, the heavy rolled sections, and the fine forgings of the Petin-Gaudet Works, the remarkable steel castings, the "phosphorus" steel rails, and the fine ship steel of Terrenoire; the enormous steel forgings and the almost innumerable rolled and hammered iron and steel shapes of Creusôt,—the second largest works of the kind in the world,—all these were conspicuous only by their absence. In reviewing the state of the art, these products must of course be considered.

Great Britain.

Great Britain was nearly as incompletely represented as France in the range of her products, although her capacity for manufacturing every variety of grade and shape required in the arts was obvious to the expert from an inspection of her limited display. The armour-plates, from the two most celebrated makers, Sir John Brown & Co. and Cammell & Co., proved the possession of the very best skill and mechanical appliances. Of the first-named maker there were a 14-inch plate, planed across to show perfect welding; an 8-inch plate, which had received nine 68-pound spherical shot at 30-feet range; and a 9-inch plate, which had received four 7-inch, pointed, chilled shot at 30-feet range. There were no cracks in the plates outside of the area of impact, and no cracks in the rear, showing great toughness and homogeneity. Two of Cammell's plates, 11-inch and 8-inch respectively, showed equally good results under proportionally severe firing tests; and in a 22-inch plate, planed across, the lines of welding were not distinguishable. But one Bessemer steel works, the West Cumberland, made an exhibit; this, however, was a fair example of the good quality and large range of steels producible from native materials. There were plates severely tested by dynamite and by cold-bending, and rails and miscellaneous bars distorted hot and cold. There were also characteristic samples of the excellent red hæmatite ore and coke employed in the manufacture. Only one open-hearth

or Siemens-Martin Works exhibited, but this one—the Landore Works—is conspicuously associated with Dr. Siemens' pig-and-ore process, and with his management, and with his successful experiments in making plates of very high quality for the Admiralty. The Landore exhibit was only a case of small samples, but the character of the tests and their obvious fairness were conspicuous proofs of the toughness, homogeneity, and uniformity of what, as now largely and cheaply produced, is a new article of commerce and manufacture, and is more properly called "ingot iron" than "steel." The only crucible steel exhibits of products larger than wire were from an eminent house,—that of William Jessop & Sons. Among them were a sheet of No. 14 gauge, 96 inches long and 24 inches wide; a disc of No. 3 gauge, $88\frac{1}{4}$ inches in diameter; and a sheet for band-saws, 223 feet 4 inches in length. The notable coils of steel wire were one of No. 12 gauge, weighing 111 pounds, the breaking strain being 1,500 pounds. This was from W. D. Houghton, of Warrington. William Smith & Son, of the same place, had a coil $\frac{1}{10}$ inch in diameter, 2,260 yards long, weighing $181\frac{1}{2}$ pounds, and capable of standing a strain of 1,580 pounds. Among the tin plates of large size and fine quality were those of Hatton & Sons, Henry Nash & Co., and E. Morwood & Sons. Thus the exhibit of Great Britain, while showing high quality, both of product and of skill, and in a certain degree high quality of machinery, in certain diverse manufactures from wire to armour-plates, nevertheless did not furnish material for estimating the quality of manufacture and of material in a very great range of products for which Great Britain is celebrated. These unrepresented products are chiefly heavy forgings of iron and steel for guns, and for parts of marine and other engines; also large rolled beams, shapes, and plates and steel castings of great size, besides the ordinary structural forms of every variety and quality.

The iron exhibits of Canada were respectable, but they were more notable as a show of materials than as an illustration of development in manufacture. The same may be said regarding several other countries. For instance, the iron ores of Spain, especially those which are combined with manganese oxides, are remarkable for their purity and value, and for their large quantity and distribution. But as in Spain, and in other countries not above mentioned which exhibited fine iron ores, the wrought-iron and steel manufactures are not so far developed as to materially affect the questions under consideration, these countries will not be further referred to in this report.

United States.

BESSEMER STEEL.

As the principal product of American Bessemer works is rails, so the bulk of their exhibit was rails of many patterns, cold-twisted and cold-bent in every variety of distortion, to show the toughness of the material. Several Bessemer works made large, costly, and instructive displays, as follows. The iron rails of some of these works will be incidentally referred to.

Albany and Renssalaer Iron and Steel Works, Troy, N.Y.

As an exhibit, this was imposing as well as complete. Rolled bars of all the ordinary rail and merchant shapes and sizes, and many unusual shapes, in iron and steel, from 30 feet long to mere "sections," also nails, spikes, horse-shoes, bolts, nuts, and miscellaneous small products, were grouped in clustered pillars and in graceful shields and festoons upon a high and elaborate screen. There were distorted iron and steel axles, small forgings fractured and bent, or polished, to show quality, welded steel bars, sections of rails at each stage of progress through the rolls, and numerous other illustrations of large range, high quality, and good machinery and processes. An additional exhibit in the United States Government Building was a noble column consisting of a 4-rail, rolled steel bloom, weighing over a ton, surrounded with a cluster of polished rails, axles, and bars, upon a base ornamented with sections and smaller products. The principal tests of quality were fractures, polished sections, cold-bends, and hot-punched and welded specimens of small special steel bars

of high quality, made with ferro-manganese, from the best and very pure ores of the Lake Champlain region. This material, as far as its quality was disclosed, seemed equal to Swedish Bessemer steel of similar grade.

Cambria Iron Co., Johnstown, Pa.

This Company made two exhibits; that of raw materials, one of the most complete shown, cannot properly be further referred to in this paper; that of iron and steel rails, which is the Company's product, although not of a character which allows much variety of display, was nevertheless grand and effective. It was a massive arch, built from a great number of rails of 60 different patterns, and from iron and steel in the early and intermediate stages of manufacture. There were also a variety of tested bars, a complete series of analyses of materials and products, and a most interesting record of the excellent endurance of iron rails especially, for a period of years. The exhibit afforded every facility for ascertaining the causes of the qualities shown, and it indicated the possession by the Company of a large and good organization, and of first-rate machinery and processes.

The Cleveland Rolling-Mill Co., Cleveland, O.

This company's products, both in iron and steel, are so numerous that their display was large, interesting, and instructive. There were specimens of Bessemer and Martin steel and iron rails, plates, sheets, bars, wire, and miscellaneous shapes and products in great variety and of good workmanship. Quality was also proved by fractures and cold-bends, and a steel rail was shown, by the side of which 34 iron rails had been worn out. The steel wire display was excellent as a display and as an illustration of good quality and superior workmanship.

The Edgar Thomson Steel Co, Pittsburgh, Pa.

This Company produce only steel rails and steel blooms and billets,—products which do not admit of much display,—yet the exhibit was in many respects the most remarkable of all. It contained a steel rail of 62 pounds per yard, 120 feet long, and several rails of lighter and heavier patterns, from 56 to 98 feet long. This is proof of excellent machinery and technical organization. There were also shown a sound 4-rail ingot, a rolled 4-rail bloom, and various sound locomotive forgings made from this Company's steel, which were tested by cold-bending. Analyses of materials and products were furnished. The finish, and especially the hot-straightening of the rails, were notable.

The Pennsylvania Steel Co., Harrisburg, Pa.

This exhibit, besides containing rails, blooms, and billets, was peculiar in containing a Bessemer ingot of 6,200 pounds weight, and some rather large and very well made forgings from similar ingots, showing a creditable progress in this important line of manufacture.

The Lackawanna Iron and Coal Co., Scranton, Pa.

This Company made a small but very good exhibit of samples of materials with analyses, and samples of crude bars and of finished and tested iron and steel rails and merchant bars. The quality of the Bessemer pig and of the best bars was remarkable. The exhibit also contained a 70-pound steel rail 84 feet 8 inches long, and various iron and steel rails distorted without fracture, all of which indicated good facilities of every kind for the manufacture.

The Bethlehem Iron Co., Bethlehem, Pa.

A very sound fractured ingot, and a few samples of bars and pigs, as a part of the Lehigh Valley exhibit. The leading character of this establishment,

however, in respect of its size, the excellence of its steel and iron rails, and its technical management, will warrant a reference to its *status* and practice, in coming to our conclusions, especially as the plant was fully illustrated by drawings in the gallery of the American Society of Civil Engineers, and as the works themselves were an important feature of the Centennial Exhibition, to many foreigners and citizens.

The North Chicago Rolling-Mill Co's Works, Chicago, Ill.

These were fully illustrated by drawings, as were also the works of the Cambria Iron Company, and those of the Edgar Thomson Steel Company, before referred to.

IRON RAIL, BEAM, AND BAR EXHIBITS.

Exhibits of various Bessemer steel establishments have already been mentioned. The Cambria iron rails were proved by official records to possess unusual durability; this was chiefly due to the excellent welding quality of the iron, and to the peculiar piling and heating which this iron requires.

The Philadelphia and Reading Railroad Co.

Crude materials, piles and iron rails illustrative of the process of manufacture at their rolling-mills at Reading, Pennsylvania; also, steel rolls rolled at these mills from ingots made at the Midvale Steel Works; also drawings of their plant. The iron rail process, by which the head is largely reworked, and the whole pile is reheated after half the passes are made, and then finished in a 2-high train, was fully described by Mr. Coxe, superintendent of these mills, in a paper before the American Institute of Mining Engineers, in June 1876, and cannot be discussed here. This process should, however, be prominent among the data from which the conclusions about the iron-rail manufacture are to be drawn, as the reheating especially has been largely copied by other works with advantage.

The Phœnix Iron Co., Phœnixville, Pa.

This exhibit consisted chiefly of sections of the "Phœnix" wrought-iron columns (a well known improvement in construction), and of structures in and about the Exhibition buildings, formed of these light and strong columns, and of other forms rolled at these works; also, drawings of the new, extensive, and highly improved plant in course of erection.

The Union Iron Co., Buffalo, N. Y.

A very excellent exhibit of heavy rolled iron, among which were a 15-inch beam, 52 feet long, weighing 3,467 pounds; a 15-inch beam, 46 feet long; a 9-inch beam, 80 feet long; a 6 by 6-inch angle, 56 feet long, weighing 1,040 pounds; a plate, 24 feet 10 inches long by 66½ inches wide by ⅜ inch thick; besides many other forms and illustrations of piling and rolling. Quality of material and of welding was shown by planing the web of a heavy beam partly in two, longitudinally, and cold-bending the top and bottom flanges apart without fracture. This exhibit proved that the plant is adapted to large work of great variety, and that the manufacture is well in hand.

Cooper, Hewitt, & Co., Trenton, N. J.

A comprehensive and highly-instructive exhibit of raw materials and pig-iron, and of wrought-iron rails, beams, shapes, bars, rods, chains, etc.; also, open-hearth steel products, systematically arranged to illustrate the stages of

manufacture and tested to prove quality. The capacity of the works to produce heavy and light rolled shapes to advantage was obvious from the exhibit The most remarkable product shown was gun-screw iron, as used by the manufacturers of arms. This material is made and welded with such great care that it is nearly homogeneous. A specimen, $\frac{5}{8}$-inch in diameter, suffered elongation to 2·2 times its original length before fracture.

The Union Rolling Mills, Pittsburgh, Pa.

Some fine specimens of large rolled shapes, and a novel and good wrought-iron column.

Messrs. Jones & Laughlins, Pittsburgh, Pa.

This firm are well known in connexion with their cold-rolled shafting and bars, and their exhibit proved that they had raised this difficult and peculiar manufacture to a high degree of perfection. The excellence of their roll-turning and straightening apparatus was illustrated by bars which make true running shafting and piston rods without turning; the increased strength and wearing qualities of the metal were amply shown.

The exhibitors of well-rolled bar-iron, of good quality, were too numerous to be even mentioned in this paper; the respective merits of their products are stated in the Reports on Awards. It would hardly be proper, however, in this connexion, to omit the names of Messrs. H. Burden & Sons, Cartwright, McCurdy, & Co., The Catasauqua Iron Co., and The Pottstown Iron Co.

IRON PLATES.

Plates shown by the Cleveland Rolling Mill Company, and of the Union Iron Company, of Buffalo, have already been referred to.

Phillips, Nimick, & Co., Pittsburgh, Pa.
Brown & Co., Pittsburgh, Pa.

Independent, although somewhat similar exhibits, that were very remarkable, both as elaborate, instructive, and splendid exhibits, and as complete proofs of extraordinary quality. Among the celebrated "Sligo" brand plates of Phillips, Nimick, & Co., where a disc 106 inches in diameter, having 64,000 pounds tensile strength per square inch; a welded pipe expansion-joint, $4\frac{1}{2}$ feet in diameter; also, various specimens of the most difficult flanging. A sligo bar, 9 by $4\frac{1}{2}$ inches in section, was bent cold to $4\frac{1}{2}$ inches internal radius without cracking, and the elaborate tests to prove the absence of red-shortness were too complex for description here. All the polished slabs and large sections were free from flaws and specks. The also celebrated "U.S." brand plates of Messrs. Brown & Co. were even more surprisingly flanged without fracture, and the toughness of the same iron was most severely tested in various ways; some $3\frac{1}{2}$-inch rods, having square and V-threads, with $\frac{3}{8}$-inch pitch cut upon them, were bent cold to 8-inch inside diameter, without exhibiting a tendency to fracture. A principal cause of the superiority and uniformity of these two brands of iron is, that the makers own the raw materials and control the processes from the beginning.

John Roach & Sons, Chester, Pa.

A boiler head-sheet, 106 inches in diameter, $\frac{3}{4}$-inch thick, and weighing 1,045 pounds. It had four 24-inch flanged openings. There were some other large plates, and some creditable specimens of plate welding.

IRON SHEETS.

W. D. Wood & Co., Conshohocken, Pa.

This large and elaborate display of iron sheets was remarkable for highly-glazed surface and good quality, and for its equality in all obvious respects to Russia sheet-iron.

Alan Wood & Co., Conshohocken, Pa.

An equally fine display, which was also conspicuous for the smoothness and accuracy of the rolling, and the toughness of the metal, as amply illustrated.

Moorhead & Co., Pittsburgh, Pa.

Beautifully-finished sheets adapted to a great variety of uses; the tests of these for stamping into hollow-ware were complete; there were some large sheets also, one, No. 24, 44 by 120 inches, galvanized; another, No. 24, 48 by 120 inches.

It would be impossible to refer in this paper to all the exhibitors of galvanized iron sheets and other articles. The names, however, of Messrs. McCullough & Co., and of Messrs. Marshall Bro[illegible]. & Co., of Philadelphia, Pa., who made excellent exhibits, cannot be fairly omitted in this connexion. The quality generally appeared to be up to the highest state of the art. N. & G. Taylor & Co., Philadelphia, Pa., had a fine exhibit of tin plates.

IRON FORGINGS.

The only large forgings of American manufacture were by Messrs. John Roach & Son, of Chester, Pa.; there was a paddle-wheel shaft 36 feet long by 22 inches in largest diameter, weighing 53,225 pounds. There was also a forged armour-plate 12¾ inches thick by 3 feet 8 inches wide by 10 feet long. It was planed on the edges to show good welding. The appearance of these forgings was very creditable. There was, however, no test o the metal by distortion.

The Edge Moor Iron Co., Wilmington, Del.

A number of hydraulic forged eye-bars and upset bar-ends for screw-threads; also, samples of hydraulic rivetting, showing that the rivet will fill even unmatched holes, while by hand rivetting it will not. This hydraulic shaping of iron, not yet largely practised in America, is most creditable to the Edge Moor Company as a modern advance in the art, and as evidence of high quality of product.

Wilson, Walker, & Co., Pittsburgh, Pa.

A good exhibit of small forgings for railway purposes.

OPEN HEARTH OR MARTIN STEEL.

The exhibit of The Otis Iron and Steel Co., Cleveland, Ohio, showed as high a state of the art, with reference to boiler-plates at least, as that illustrated by any Swedish exhibitor. There were shown a very heavy plate 21 feet 2 inches long by 6 feet 2½ inches maximum width by ½ inch thick, weighing 2,670 pounds, with untrimmed but very true edges, it having been rolled directly from a 9-inch thick ingot, and not from a hammered slab; also, a ½-inch head sheet 88 inches in diameter; also, sound fractured ingots and some forgings. Among the tests were ⅝-inch and 1-inch plates, bent cold,

fourfold, under the hammer, and a $\frac{5}{8}$-inch plate, having sound cups 5 inches deep and close together, indented cold by a 7-inch cannon-ball driven into it by a steam-hammer, the anvil being a 7-inch ring. The specimens of flanging were also very good. There were also a large number of tested specimens accompanied by the official records of strength and elongation. The general results of these tests were equal to any which were exhibited.

The Midvale Steel Works, Philadelphia, Pa.

This exhibit was extensive in range, and it showed evidences of excellent control of materials and processes, so as to turn out uniform products. For tyres, the aim is the greatest hardness consistent with toughness; as a type, a $55\frac{3}{16}$ (inside) tyre was reduced by 15 tons hydraulic pressure to $54\frac{7}{8}$ inches in lesser diameter, without permanent set; 25 tons reduced it to $54\frac{5}{8}$ inches with $\frac{1}{8}$ inch set; 53 tons gave $26\frac{3}{4}$ inch set and broke the tyre. Railway axles are made from Bessemer pig and good scrap and charcoal blooms, so as to be especially free from brittle ingredients; still, they are made hard enough to wear well by means of 0·30 per cent. carbon, and tough enough to stretch 26 per cent. with 68,000 pounds tensile pull, and 33,000 pounds limit of elasticity. They are hammered from 12-inch 3-axle ingots. There are four classes of steel for forgings and structural purposes; the tensile strength runs up to 94,000 pounds with 17 per cent. elongation. Tyre steel has about 90,000 pounds tensile strength and 20 per cent. stretch. There were exhibited various fractured and tested specimens of the above-mentioned products. There were a 7,000-pound ingot 20 inches square, fractured ingots showing notable soundness, various solid, smooth machinery castings, a group of bottom-cast tyre ingots, and a 5,000-pounds hammered piece $12\frac{3}{4}$ inches by 12 feet for a gun tube; this had 54,000 pounds limit of elasticity, 83,000 pounds tenacity, and $16\frac{1}{2}$ per cent. stretch. The exhibit illustrated the best state of the art in the United States in respect of heavy work.

The Nashua Iron Co., Nashua, N. H.

Sound and well-manufactured forgings, among them locomotive cranked axles and a 7,500 pound shaft; also locomotive tyres, and a variety of fire-box and boiler-plates, which, as far as means were provided for determining, were of good quality. This is the only works of the kind, in fact, the only rolling-mill in the State.

The Bay State Iron Co., Boston, Mass.

A collection of fire-box and other large ingot-iron plates, some of which were flanged; they were made by the Martin process, and appeared, as far as tested, to be of high quality.

Singer, Nimick, & Co., Pittsburgh, Pa.

A very fine exhibit of saw-plates; also open-hearth boiler-plates and sheets of various thicknesses. The plates were rolled in a Lauth 3-high train, and the surfaces were notably smooth and clean. This company also made exhibits of crucible steel, which were of good quality.

CRUCIBLE STEEL.

The exhibits in this department, from the United States, and especially from Pittsburgh, were remarkably extensive and fine, and they had (excepting heavy forgings) the largest range of size, shape, temper, and adaptation known in the arts.

Park Bro. & Co., Pittsburgh, Pa.

This firm made two displays; the one in the Government Building especially was very beautiful, instructive, and complete as an exhibit; it began with

the crude materials, and showing all stages of manufacture, ended in a most elaborate grouping of numerous rolled and hammered shapes, severely-tested plates and bars, and a vast variety of tools and implements. The number of uses to which both the hard and soft grades of the material were applied was worthy of attention. The capacity of ingot-iron to combine perfect soundness with great strength, high extensibility, and extreme malleability was best shown by the severe cold-tests and complex flanging of boiler plates. The whole exhibit would have been creditable in every respect to any establishment in Sheffield, the old and principal seat of the steel manufacture.

Miller, Metcalf, & Parkin, Pittsburgh, Pa.

An exhibit, of which a number of old, worn, and thoroughly-tested special tools, the service of which was stated, was a most interesting and creditable feature. An intelligible explanation of the service and endurance of these tools would be too long for this paper: it is sufficient to say that this company proved its capacity to adapt steel uniformly to a large number of uses requiring not only the very highest general quality, but very various special physical properties.

Hussey, Wells, & Co., Pittsburgh, Pa.

An instructive exhibit in the Government Building, and a fine display, well illustrating high quality, in the Main Building. There were large and elaborately flanged boiler heads, severely tested railway axles, plates folded hot and cold without fracture, and forgings of very clean steel; among others, a finished bar 31 feet 8 inches long by 4 inches in diameter. Perhaps the feature which attracted the most expert attention was the large size and extremely good finish of the many sheets which were displayed.

The Chrome Steel Co., Brooklyn, N.Y.

Steel in various forms, and compound bars of soft iron and hard steel for safes. Although the proof of quality was limited, it is well known that the use of chromium has developed some extraordinary and valuable qualities in steel.

Reese, Graff, & Woods, Pittsburgh, Pa.

A large variety of shapes in wrought as well as in steel of all grades.

The Standard Steel Co., Lewistown, Pa.

A number of locomotive tire ingots, "cheeses," punched and beaked rings and finished tires, which, although not tested, are known to be of good quality.

The Adirondack Steel Works, Jersey City, N.J.

These works, established as early as 1848, showed a large variety of hammered and rolled bars and small forgings, which looked well.

STEEL AND IRON WIRE.

The exhibit of the Cleveland Rolling Mill Company has been referred to.

The Washburn & Moen Manufacturing Co., Worcester, Mass.

The display of this company was splendid in itself, and as an illustration of range and quality in the wire manufacture it was exhaustive. There were

materials such as iron and steel blooms, and wire rods of extra lengths without welds, also wire covered with zinc, tin, and other metals, and wire for telegraphs, cards, pins, brooms, weaving machines, and musical instruments. Superior workmanship, exactness of size at both ends of the coils, and large and excellent facilities for manufacture, were conspicuously illustrated.

Stewart & Co., Easton, Pa.

A good display of well-finished wire.

MISCELLANEOUS.

In addition to the exhibits mentioned, there was a large display of drop forgings and also of springs, and a vast and excellent show of iron and steel tools, implements, and hardware in great variety, which cannot be properly referred to in this paper. It is, however, within the province of this paper to call attention to the remarkably excellent display of American drop forgings, as illustrating not only the character of the tools and the materials represented in their fabrication, but also as leading up to the manufacture of large hydraulic forgings, in which the German works are so eminent, and in which our own are so deficient.

The Exhibit of the United States.

Great as was its magnitude and range, this exhibit did not equally represent the respective magnitudes and ranges of the iron and steel manufactures in its several iron-producing districts, but it did fairly illustrate the resources of the United States and the technical development of the manufacture and the probable direction of improvement. The resources of the country were perhaps more amply represented by the vast and various groups from all its parts, of iron ores and other minerals necessary to the manufacture, than by the samples of iron and steel products. The exhibit of the United States, however, was not chiefly significant as an illustration of possibilities, it was a complete and comprehensive proof of accomplished results. It established the fact that the manufacture is carried on over a wide range of territory and on a scale only exceeded by that of Great Britain, and that it is highly organized and scientifically conducted in most of its departments. But while the manufacturers of this country deserve this degree of credit they are, unfortunately, open to criticism in two important directions: first, they are a long way behind English, French, and German manufacturers in the substitution of steel for wrought-iron and cast-iron in all uses, from ships, engines, and ordnance down to hardware; and, second, they have hardly introduced the system of hydraulic forging, which the German and French exhibits proved to be not only practicable and economical within a very large range of products of moderate weight, but also capable of safe extension to forgings of large size. The incapacity of American works to produce large steel hammer-forgings may be explained on other grounds than want of enterprise or technical knowledge on the part of manufacturers. Such forgings are chiefly required for steamships and for cannon. Unfortunately, and for reasons which cannot be discussed in this paper, there has not been a sufficient demand for steamship shafts to warrant the erection of the extensive plant required to produce them in steel; fortunately, the necessity for ordnance of great power has not been so imminent as to warrant the reproduction of another Woolwich Arsenal in this country. The excellence of American cast-iron, and the considerable cost of the plant to make hydraulic forgings as a substitute for cast-iron, may be put forward as an excuse for our slow development in the large and cheap adaptation of steel to general uses; but if the steel exhibits of Germany especially in this direction have shown our iron and steel-makers and users the fallacy of this idea, the Exhibition will have been worth to them many times its cost.

The State of the Art.

Having described generally the exhibits of wrought-iron and steel, it seems also important, in order to determine the status of these manufactures in our

Centennial year, briefly to refer to the methods of manufacture, and to the character of plant in use in the chief iron-producing countries. The necessary data for such reference were largely obtainable from the drawings, models, and statistics of foreign exhibitors, and more especially from those of American exhibitors in the halls of the American Society of Civil Engineers and of the American Institute of Mining Engineers, which institutions, both separately and unitedly, and both by exhibits and by means of their social facilities and their excursions to mineral and manufacturing regions, connected the general industry with the Centennial Exhibition. But as various countries and districts were inadequately represented, and as exhibits of product alone cannot fully represent the character of plant and processes, the writer has ventured to supplement the information derived from the Exhibition itself by further information derived from personal observation of the art at home and in foreign countries just before and immediately after the Exhibition.

THE BESSEMER MANUFACTURE.—In Great Britain and on the Continent the original, and, as meeting a new requirement, the extremely ingenious and highly organized plant of Bessemer and Longsdon, has been pretty rigidly adhered to; it is only in several of the latest works abroad that any attempt has been made to improve it, or even to bring it up to the standard established elsewhere. In the United States, while the excellent features of Bessemer and Longsdon's plant have been retained, the very first works, and in a better manner each succeeding works, have embodied radical improvements in arrangement and in detail of plant, the object being to increase the output of a unit of capital and of a unit of working expense. It would be impracticable in this paper to explain in intelligible detail the character of these improvements, but any one who wishes to pursue the subject further will find an illustrated analysis of the American Bessemer plant in *Engineering*, London, March 9 and 16, 1877. The close of the article referred to is as follows:

"In conclusion, it will have been observed that the capacity of these works for a very large and regular output lies chiefly in an arrangement which provides large and unhampered spaces for all the principal operations of manufacture and maintenance, while it at the same time concentrates these operations. The result of concentration which is realized is the saving of rehandling and of the spaces and machinery and cost required for rehandling; a possible result of concentration which has been avoided is the interference of one machine and operation with another. At the same time a degree of elasticity has been introduced into the plant, partly by the duplication and partly by the interchangeableness of important appurtenances, the result being that little or no time is lost if the melting and converting operations are not quite concurrent, or if temporary delays or failures occur in any department of manufacture or maintenance.

"The fact, however, must not be lost sight of, that the adaptation of plant, which has thus been analyzed, is not the only important condition of large and cheap production; the technical management of American works has become equally improved. Better organization and more readiness, vigilance, and technical knowledge on the part of the management have been required to run works up to their capacity, as their capacity has become increased by better arrangement and appliances.

It may be stated generally that the average output of a pair of 5½ to 6-ton Bessemer vessels in the United States in 1876 was 225 to 250 tons of ingots per 24 hours, and that such a plant has produced not less than 350 tons of ingots in 24 hours. The largest output of any British works was 180 tons out of a pair of 7-ton vessels in 24 hours. The product of the best Belgian works is about the same. In all the foreign works which make a large output the arrangement which distinguishes the American plant has been more or less adopted.

The direct use of blast-furnace metal in the converter without remelting has for some years been successfully employed in France, Belgium, and elsewhere with pretty uniform irons containing some 5 per cent. of manganese. The oxidation of this large amount of manganese and of a small amount of silicon makes the charge hot enough to cast without an excess of scrap. At the same time, any remaining manganese becomes a useful ingredient in the steel. In fact, with such irons, the blowing is in some works stopped (by means of slag

colour tests and the mechanical test of globules of steel in the slag), while the charge still retains enough carbon and manganese to constitute the desired grade of steel, and no more manganese is added. The direct use of blast-furnace metal in Great Britain from the native and foreign ores which are best obtainable there, and which do not contain much maganese, has been practised for a shorter period and with less marked, although substantial, success. In the absence of manganese, the necessary heat is generated only by means of an excess of silicon, and highly siliconized irons have a tendency to make a brittle product in the Bessemer converter, for reasons which are not as yet perfectly understood. The direct use of blast-furnace metal has not been attempted in American Bessemer works, although several of the more recent ones were arranged for this practice; and on account of the small or irregular proportions of manganese in the American Bessemer ores best obtainable, the results would correspond to those in Great Britain. When, by means of rapid analyses, uniform materials, better control of heat, or by any other instrumentalities, the blast-furnace makes a product as uniform and suitable as that which may be obtained by the selection of pigs, the direct process will of course effect a very large saving in the cost of steel. A similar result may follow the attempt just making in England, to mix large quantities of fluid blast-furnace metal from different furnaces, and to store it for some hours, as required, in tanks or in open-hearth furnaces.

The cheap production, in the blast-furnace, of spiegeleisen containing as much as 20 per cent. of manganese, and also the production, at a reasonable cost, of still richer ferro-manganese, have enabled Bessemer steel-makers to largely vary and improve their products. The use of manganese as a flux and as an ingredient of steel, up to 1 per cent. and above, has proved in every way valuable.

Conspicuous and rapid as have been the improvements in the Bessemer steel manufacture,—chiefly due to better engineering and to the selection of materials by means of chemical analysis,—the adaptation of impure ores (chiefly the elimination of phosphorus) has made no progress whatever. While the proportion of phosphorus may be safely increased a little, if carbon is kept very low and manganese is used freely, it is nevertheless true, in general terms, that the best grades of ores are necessary to the production of the best grades of Bessemer steel.

There are in the United States eleven Bessemer works, having in all 22 vessels, with a capacity of at least 550,000 tons of ingots in the aggregate.

The Open-Hearth Steel Manufacture.—The Martin process and the great and controllable temperature of the Siemens regenerative gas-furnace, offer remarkable facilities for producing steel of every grade from a variety of materials. Yet this manufacture, for some years, made little headway, especially in the United States (where but eighteen furnaces are in operation), for various reasons, chiefly the difficulty of maintaining the furnace. But within a few years it has, especially in France, been largely developed and cheapened in various directions. At the Terrenoire Works, the output has increased from less than two to about three charges per furnace per twenty-four hours, and in addition to the usual grades of steel made by dissolving steel or good wrought-scrap in a bath of pig-iron, two important modifications of the manufacture are in regular and successful operation:

1. Rail steel, of a quality good enough for French roads, at least, is made by melting down about two parts of old and highly-phosphorized iron rails and one part of good pig-iron, and then adding enough ferro-manganese to produce a steel with 0·20 to 0·25 per cent. of phosphorus, about 1 per cent. of manganese, and but 0·12 to 0·15 per cent. of carbon. The reason why phosphorus does not make steel cold-short in the presence of this low carbon and high manganese is little understood, but the fact that manganese promotes toughness and soundness is as well ascertained, and is as important in the open-hearth, as in the Bessemer process.

2. The Terrenoire Company have also developed the manufacture of sound steel castings, which have as high a specific gravity as rolled steel, as well as the strength and physical properties generally of rolled or hammered steel of equal hardness. Although steel castings are more or less successfully made elsewhere by means of manganese and silicon, this process is original in

following a scientific order of chemical reaction of silicon and manganese, the object being to partly prevent and partly remove the causes which in ordinary steel-making produce unsoundness and want of solidity. It would be impracticable to further describe this important manufacture within the limits of this paper.

At St. Chamond, in France, M. Charles Pernot has for some years experimented with, and has recently brought to a high state of efficiency, an open-hearth furnace with a revolving hearth, by means of which the mechanical agitation of the bath is made, as in the Bessemer process, to facilitate the chemical reactions. This furnace makes about 3½ heats from cold materials in 24 hours, and is very economical of fuel.

Dr. C. W. Siemens has during the last three or four years developed, chiefly at the large works of the Landore Siemens Steel Company in Wales, the "pig-and-ore process," which consists in melting down a charge of pig-iron, together with enough iron ore to make good the loss of pig-iron by oxidation. The ore facilitates the decarburization of the pig-iron. The pig-and-ore process is coming largely into use, and is in Great Britain, where it is well done on a large scale, a successful rival of the Bessemer process, which is not, comparatively, as well done.

Dr. Siemens has also quite recently enlarged the size of the open-hearth furnace, and has greatly improved the mixing of the air and gas; and he and others have materially increased the durability and efficiency of the apparatus, chiefly by means of giving proper direction to the flame, and by developing the manufacture of more refractory bricks and bottoms. At the latest works in England 10-ton and 12-ton furnaces are employed, while some 3-ton furnaces are still used in the older works. There are above 80 furnaces in operation in Great Britain. In the convenient arrangement of open-hearth plant, more has been done in the United States than abroad, although the extent of the manufacture in this country is quite small, no establishment having as yet more than three furnaces, while at the Landore Works there are twenty-four.

The use of iron direct from the blast-furnace, or from the cupola, has not been found to facilitate the open-hearth manufacture; solid pig is purified as it is melted on the open-hearth, and the purification of fluid pig appears to require as much heat and as much time. Unlike the Bessemer, the open-hearth process provides conditions for the partial elimination of phosphorus, and for the more complete oxidation of silicon. Phosphorus is oxidized at a low temperature, but as the temperature rises to the point at which steel will remain fluid, the affinities appear to change, and phosphorus goes back into the iron. It is obvious that the open-hearth process, and more especially the puddling process, are, on account of the long exposure of the bath to oxygen, and of the separation of the slags from the metal throughout the operation, more favourable than the Bessemer process to the removal and detention of the phosphorus in the slag. The open-hearth process presents these favourable conditions: it allows a certain elimination of impurities; the necessary heat is not dependent on the proportion or regularity of silicon or manganese in the pig-iron; hence, and because it may use ore and old iron of inferior quality, its materials may be very cheap; at the same time, with the best materials, and with the accurate means of test and control which the operation furnishes at all stages, it may produce very high and very uniform qualities of steel of every degree of temper and adaptation. Although not now as cheap in the United States as the Bessemer process, it is evidently a growing and important department of the steel manufacture. The excellent character of its products were as conspicuously shown in the exhibits of the United States as in those of any foreign country.

Direct Ore Processes.—This subject is mentioned in connexion with the open hearth, because if the direct process of producing spongy iron becomes a complete success, it will be a most important auxiliary to the open hearth; it will provide a cheap material, which will be at the same time pure, because it has been made at a low temperature, and is hence not incorporated with the phosphorus and other impurities which blast-furnace products would get out of the ore. The theoretical attractions of the direct process are equalled only by its practical difficulties. Since the dawn of the iron manu-

facture it has been the subject of numerous experiments, but of very limited and expensive practice. The process of Dr. C. W. Siemens, of Landore, now in commercial use both in England and in America, seems to possess the elements of success; it, however, does not follow that the process of Mr. Thomas S. Blair, of Pittsburgh, Pennsylvania, may not also succeed, when it has been as fully matured. Both these processes have made material for excellent steel. Blair's consists in deoxidizing the ores rapidly by gas and solid fuel, but without fusion, and then withdrawing the iron-sponge cold, without allowing it to oxidize again. The sponge is compressed and charged into the open-hearth furnace, or it is reheated or charged, or it is melted in a cupola and then treated in the open hearth. The best manner of using the sponge does not appear to be fully settled. Siemens' process consists in melting ore, together with coal and limestone enough to reduce it, in a rotating furnace, tapping off such slag as will run, squeezing the remaining slag out of the ball, and charging the ball hot into the open-hearth furnace. The radical trouble in all direct processes has been the waste of iron in getting it from the sponge into merchantable form. The addition of the open-hearth process greatly relieves this difficulty. The Centennial year of the republic, and the Centennial year, at least, of the direct process, seems to have witnessed the beginning of success in this most simple and yet most difficult art.

The Crucible Steel Manufacture.—A very few words will suffice for the state of this art. The cost of the process has been quite revolutionized by the use of the Siemens gas-furnace, which produces a ton of steel with 1 ton of slack coal, while $2\frac{1}{2}$ to 3 tons of coke are used in the old form of furnace. It is, however, a rather remarkable fact that this revolution has been almost exclusively confined to American works, and that Sheffield, England, the chief seat of the business, has not largely adopted the gas-furnace. The other important improvement in the manufacture (since the improved use of manganese) has been the better chemical knowledge and selection of materials. Chromium and various fluxes have more or less enlarged the range and value of steel treated with these substances. The crucible is yielding place to the open hearth and to the converter for large work and for constructive uses generally on account of both the cheapness and the uniformity of the large masses made by the large-scale method. The crucible seems, however, destined to long hold its place for the production of tools and other very fine steels, because the whole of the material it employs may be selected from the most highly-refined direct process or puddled products, while the Bessemer and the open hearth must use more or less crude cast-iron.

The Wrought-Iron Manufacture.—With the exception of mechanical puddling, no revolutionary or very important modification has been generally adopted, although many details of plant and process have been improved. Many fluxes have been the subject of experiment, but none except fluor-spar in some shape have been much employed. Larger furnaces and preheating chambers have come more or less into use. Numerous forms of apparatus for heating blast by the waste gases, and for promoting better combustion and for saving fuel, having been locally adopted with some success. The regenerative gas-furnace has realized a great economy in fuel and in some other respects, but the fluxing of regenerator bricks by the fine particles of oxide of iron which pass into them with the draft has been its most serious obstacle. Improved regenerators which can be readily cleaned are the subject of promising experiments by Dr. Siemens and others. The retort-furnace of Mr. John Price, used for puddling and heating at the Woolwich Arsenal and elsewhere in England, is giving very good results, especially in fuel, and it has the advantage of cheapness. The hot gases as they leave the furnace heat a body of coal in a retort connected with the fire-box, thus distilling the hydro-carbons, which then pass steadily over the fire and intercept any air which may enter through the grate. The fire on the grate is regularly replenished, not with cold and damp coal, which would check the combustion and disturb the metallurgical operations, but with hot coke, which keeps up an even temperature. Part of the waste gases are employed to heat the blast.

Mechanical puddling by means of rabbles worked by steam-power (especially Witham's mechanical rabble) has made some progress, but the radical improvement in puddling is the adaptation of the revolving furnace. The name of Samuel Danks should always be connected with the system of maintaining oxide linings and the general arrangement and adaptation of apparatus, which constitutes the beginning of success. But his success was not complete, and it was not until after several years' costly experimenting that, at about the close of the Centennial Exhibition, three firms, one in America, one in England, and one in France, made a commercial success of mechanical puddling,—Messrs. Graff, Bennett, & Co., of Pittsburgh, Messrs. Hopkins, Gilkes, & Co., of Middlesborough, and Messrs. Schneider & Co., of Creusôt. The latter establishment has produced as much as 18 tons of puddled iron per furnace per 24 hours. Mechanical puddling has always improved the product as compared with hand-puddling; the trouble has been with the furnace and not with the process, and it has shown itself in the form of delays, which have eaten up the savings. Just now very thorough investigations are going on, especially in England, regarding the still better removal of phosphorus by means of treating the iron with oxides, at low temperature, in the mechanical furnace, with reference to the production of a material fit for steel, from highly impure ores. As the machinery for squeezing large balls is improved, it is also expected that mechanical puddling will produce heavy, strong, and nearly homogeneous masses from single balls, and out of the most impure and cheap materials, and hence at a low cost.

Meanwhile, other inventors have developed forms of rotating puddling-furnace different from Danks'. Mr. William Sellers, of Philadelphia, has successfully combined improved mechanical details with the use of gas fuel, and has protected the linings by water jackets; Mr. T. R. Crampton, of London, is employing pulverized coal as fuel in a number of furnaces; Messrs. Godfrey and Howson, of Middlesborough, have simplified the form of apparatus; Mr. Charles Pernot, of St. Chamond, has introduced a revolving hearth slightly inclined from the horizontal, and various iron-makers are experimenting in different directions. It is not too much to say that the Centennial year witnessed a fresh start, all along the line, in mechanical puddling, and that hand-puddling can hardly be practised much longer.

Rolling and Forging Machinery.—The improvements in rolling-mill machinery have not quite kept pace with those in the steel manufacture, although they have been considerable. They have consisted chiefly in the direct application, without gearing, of better steam-engines; in arrangements of parts adapted to producing more and larger work, and in machinery for feeding heavy pieces into the rolls by steam-power, thus economising labour. The old kinds of 2-high roll-trains, the one running continuously in the same direction and doing work upon the piece on its forward and not on its return passage, and the other kind, reversed at each passage of the piece by complex gearing, have nearly given place to two rival systems, viz., (1) the 3-high train, which does work at both passes, and the 2-high train, driven by a reversing engine. The 3-high system requires tables to carry the piece vertically, as well as machinery for otherwise moving it, and hence its feeding arrangement is complex and costly, although it has been highly developed by Fritz and others. In most American Bessemer works ingots to make three rails to five rails each are rolled from about 14 inches square to 7 inches square in less than four minutes by the labour of only three or four men; (2) the reversing engine has been wasteful of steam, but as now made, compound, it is more economical, and it requires a simple feeding apparatus, which may be made both strong and cheap. This system is constantly gaining ground in Great Britain and on the Continent, but it has as yet made little progress in America. The rolling of double-length rails has also made more progress abroad than at home. The feeding of long pieces, such as rails, into a roll-train has been little developed, but is beginning to engage the attention which its importance demands; not less than 10 men are now required to feed a rail-train. The "continuous mill," having alternate vertical and horizontal rolls in a row, the piece being worked by all the rolls at once, has been highly developed for small work, but not yet for large work. The improvement of mills for rolling tyres, and for special work, is making

respectable but not notable progress other than in the matter of better proportions and workmanship.

Forging machinery of the steam-hammer variety seems to be making progress, both in size and adaptation, commensurate with that of the iron and steel manufacture at large. The Centennial year witnessed the construction (not yet quite completed) at Creusôt of a steam-hammer having a 60-ton head falling nearly 17 feet, and an anvil-block weighing 720 tons. The adaptation of small hammers to miscellaneous as well as to special work, giving them almost the dexterity of a smith's arm, has been equally remarkable, both in this country and abroad. Hydraulic forging machinery, especially for steel, which is so well adapted to receive complex shapes in this manner, has made slow but constant progress, and has arrived at a considerable degree of excellence, as was well illustrated by the German exhibits; unfortunately there were almost no such exhibits in all the vast display of the United States.

Statistics.

In view of the fact that the statistical history and the *status* of the iron and steel manufacture all over the world have been fully set forth in various documents connected with the Centennial occasion, and more especially in the complete and voluminous reports of the secretary of the American Iron and Steel Association, it has been deemed best not to go much beyond the limits of technical description and discussion in this paper. As a commentary, however, on the progress and state of the art, a brief record of past and present output is appended. It has been compiled from President A. S. Hewitt's address before the American Institute of Mining Engineers, June 1876, Mr. John B. Pearse's *History of the Iron Manufacture*, 1876, Mr. James M. Swank's *Reports* (American Iron and Steel Association), 1876 and 1877, and Scrivenor's *History of the Iron Trade*, 1841.

Mr. Hewitt says, "The extent of the American iron manufacture, during "the ante-revolutionary period, can be inferred only from scanty records of "exports. These, beginning in 1717 with 3 tons, had increased in 1750 to "about 3,000 tons; in 1765 the total is reported at 4,342 tons; and in 1771 "at 7,525 tons, the maximum annual export."

Mr. Pearse says, "During 24 years, between 1729 and 1755 (excluding "1737, 1738, and 1739, for which no records exist) Virginia and Maryland "exported to Great Britain $50{,}958\frac{73}{100}$ tons of pig iron and $975\frac{13}{100}$ tons of "bar iron, an average of $2{,}123\frac{11}{100}$ tons of pig iron exported yearly . . . . "There were in Massachusetts in 1874 76 iron-works, many of them small. "The surveyor of His Majesty's woods reports shortly after 1750 6 furnaces "and 19 forges for making iron in Massachusetts. . . . Calvert wrote in "1737, 'that in Rhode Island they make anchors of all sizes and export "'them to neighbouring colonies.' . . . In 1775 the shipments from the "port of New York were 2,400 tons of pig iron and 750 tons of bar iron, and "in 1776 they were 800 tons of pig iron and 690 tons of bar iron. The pig "iron was then valued at 3*l.* 15*s.* sterling and the bar iron at 17*l.* sterling "per ton. . . . In 1749 Pennsylvania made not far from 470 tons of bar "iron yearly. . . . There were also exported from Philadelphia, for the "years 1771, 1772, and 1773, the following amounts of pig and bar iron, "taken together, viz., 2,358, 2,205, and 1,564 tons. . . . In 1789 there "were in Pennsylvania 16 furnaces, making 6,150 tons of pig iron, and "34 forges, making 1,800 tons of bar iron and 1,000 tons of castings.

"In North Carolina no iron was made until shortly before the Revolution, "and then they had one furnace and one forge. The first iron-works was "built in South Carolina only two years before the Revolution.

"In accordance with the Act of 23 Geo. 2 (1749) the governors of all the "American colonies returned the number of rolling or slitting-mills, plating-"forges, with tilt-hammers and steel-works in their district. Massachusetts "Bay had two slitting-mills, one plating-forge, and one steel furnace; Con-"necticut, six plating-forges and one steel furnace; New York, one plating-"forge, not in use, and one steel furnace; Maryland, one plating-forge, with "two tilt-hammers; New Jersey, one slitting-mill, reported not in use;

" Pennsylvania, one slitting-mill, one plating-forge, and two steel furnaces.
" All these works were, of course, suppressed till the colonies declared their
" independence."

Statistics of the Iron Trade of Pennsylvania.

1759.

12 furnaces (Acrelius), estimated	- -	5,000 tons pig iron.
12 forges and 1 bloomery (Acrelius), estimated		975 „ bar iron.

1780.

17 furnaces (Hasenclever), estimated	- -	6,000 tons pig iron.
25 forges (Hasenclever), estimated	- -	2,800 „ bar iron.
2 steel works (blister), estimated	- -	150 „ steel.

From Mr. Pearse's book it may be estimated that there were in operation about 1776—

In Virginia	-	7	blast furnaces and	3	forges.
„ Maryland	-	8	„ „	10	„ and 1 slitting-mill.
„ Massachusetts	-	6	„ „	8	„ 2 „
„ Rhode Island	-	1	„		
„ Connecticut	-	3	„ „	7	„
„ New York	-	6	„ „	3	„
„ New Jersey	-	5	„ „	5	„ 1 „
„ Pennsylvania	-	2	„ „	8	„
„ North Carolina	-	1	„ „	1	„
„ South Carolina	-	1	„ „	1	„

or 40 blast-furnaces, 46 forges, and 4 slitting-mills, with a total capacity of 20,000 tons of pig iron and 5,000 tons of bar iron.

From Mr. Swank's *Reports* for 1876 and 1877 the following statistics have been obtained. The quantity of colonial iron exported to England in 1775 and 1776, as compiled from Scrivenor's *History of the Iron Trade*, was :—

	Pig Iron.	Bar Iron.
1775 -	2,996 tons 0 cwt. 2 qrs. 24 lbs.	916 tons 5 cwt. 2 qrs. 11 lbs.
1776 -	316 „ 1 „ 2 „ 8 „	28 „ 0 „ 0 „ 0 „

In the year 1770, according to Timothy Pitkin, the following quantities of iron were exported to all countries, including England: pig iron, 6,017 tons, valued at $145,628; bar iron, 2,463 tons, valued at $178,891; castings, 2 tons, valued at $158; and wrought iron, 8 tons, valued at $810.

Early Statistics of Foreign Countries.

(From Scrivenor's *History of the Iron Trade.*)

In Great Britain in 1740 there were 59 furnaces, making 17,350 tons pig iron.
„ „ 1788 „ 85 „ „ 68,300 „ „
„ „ 1796 „ 121 „ „ 125,079 „ „
„ „ 1806 „ 233 „ „ 258,206 „ „
In 1718 there was *imported* from all countries into England 17,236 tons of iron of all kinds.
In 1734 there was *imported* 4,156 tons of steel.
In 1776 there was *imported* from all countries 49,856 tons of bar iron and 316 tons of pig iron.
In 1786 there was *imported* 48,565 tons of bar iron.
In 1735 there was *exported* to all countries 77,000 tons of iron of all kinds.
Spain exported to Great Britain in 1755 969 tons.
„ „ „ 1786 50 „
Sweden manufactured in 1748 40,600 tons of iron of all kinds.
„ „ „ 1803 48,000 „ „
„ „ „ 1812 60,000 „ „

Norway manufactured in 1791 7,653 tons of iron of all kinds.
Russia, in 1784, exported to all countries about 50,000 tons of iron of all kinds.
France, in 1784, manufactured 27,700 tons of iron of all kinds.
„ 1824 „ 334,200 „ „
Belgium, in 1822, manufactured 59,000 tons of iron of all kinds.
Austria, in 1830, in Styria, manufactured 20,000 tons of iron of all kinds.
Saxony, in 1837, manufactured 10,000 tons of iron of all kinds.
Hungary, in 1830, manufactured 9,000 tons of iron of all kinds.
East Indies, in 1833, manufactured 2,500 tons of pig iron.
One statistician gives the amount of iron of all kinds made in Europe in 1837 as 1,500,000 tons.

Statistics for 1876.

Cast or Pig Iron by Countries.	Year.	Gross Tons.	Per Cent of Total.
Great Britain	1875	6,365,462	46·52
United States	1876	1,868,960	13·66
Germany	1874	1,660,208	12·13
France	1876	1,449,537	10·59
Belgium	1875	541,805	3·96
Austria and Hungary	1875	455,227	3·33
Russia	1874	514,497	3·76
Sweden	1875	350,525	2·56
Luxemburg	1874	246,054	1·80
Italy	1872	26,000	·19
Spain	1872	73,000	·53
Norway	1870	3,975	·03
Mexico	1876	7,500	·06
Canada	1876	7,500	·06
Japan	1874	5,000	·04
Switzerland	1872	7,500	·06
Turkey in Europe and Asia	—	40,000	·29
Australasia	—	10,000	·07
All other countries	—	50,000	·36
Total		13,682,750	100·00

The world's production of pig iron, from the latest returns, in tons of 2,240 lbs.	13,682,750
Whole number of completed blast furnaces in the United States, January 1st, 1876	713
Annual capacity of all the furnaces in net tons	5,439,230
Whole number of rolling-mills, January 1st, 1876	332
Whole number of single puddling furnaces (each double furnace counting as two single ones)	4,475
Total annual capacity of all rolling-mills in finished iron, net tons (including rails)	4,189,760
Annual capacity of all the rail mills in heavy rails, net tons	1,940,300
Number of Bessemer steel works, January 1st, 1876	11
Annual capacity in ingots, net tons	500,000
Number of Bessemer converters	24
Number of open-hearth steel works, January 1st, 1876	16
Number of open-hearth furnaces*	22
Annual capacity in ingots, net tons	45,000
Number of crucible and other steel works, January 1st, 1876	39
Annual capacity of merchantable steel, net tons	108,250
Of which there are of crucible steel, in net tons	45,000

* There were but 18 open-hearth furnaces in use for the manufacture of steel.

Number of Catalan forges making blooms direct from the ore, January 1st, 1876	39
Annual capacity in blooms and billets, net tons	59,450
Number of bloomeries, January 1st, 1876, making blooms from pig iron	59
Annual capacity in blooms, net tons	60,200

Iron and Steel production of the United States in 1876 *in Net Tons of* 2,000 *pounds.*

Pig iron	2,093,236
All-rolled iron	1,509,269
Bessemer steel ingots	525,996
Crucible cast-steel	39,382
Open-hearth steel	21,490
All other steel	10,306
Blooms from ore and pig iron	44,628

Domestic exports of iron and steel, and manufactures thereof, from the United States to all countries during the calendar year 1876, currency value - $15,997,643

Conclusions.

In the foregoing description of the exhibits, and of the state of the art, it has been so far attempted to discuss the past and further development of the manufacture, that a brief recapitulation of the implied conclusions will fulfil the objects of this paper.

1. From a technical point of view it should appear that the chief iron manufacturing countries of the world are, to a certain extent, keeping pace with one another in their general results. About the same output, not of works selected at random, but of large districts in all these countries, is beginning to be got out of a unit of labour and a unit of material. Furnaces, Bessemer works, and rolling-mills are not indeed equally well planned and run, but in no district is everything either very well or very badly done. Protection, trades-unions, the development of cheaper transportation, the opening of new markets, and various other causes must of course largely affect the manufacture in its commercial features, but in its technical features there is a growing and general adoption of improvements, wherever developed; there is less conservation of what is bad and more giving and taking of what is good. Indeed, a truly scientific feeling is beginning to actuate manufacturers at large, and while it prevents any one from getting a great advantage over all his competitors, it benefits the public at large by cheapening products, and it equally benefits manufacturers by enlarging the range of production because it is cheap. For this reason there is an approach to uniform excellence, not in all the special exhibits, but in the general display of different countries. This important result has been largely developed by International Exhibitions, and equally by the transactions and social meetings of the various scientific societies connected with the iron and steel manufacture.

2. But while there is this general co-operation in developing and in adopting improvements, there are still some striking exceptions. Those which chiefly concern us in the United States, as indicated by the Exhibition, are our comparatively small application of the finer metals, such as the constructive steels, to the large and numerous uses to which they are applied abroad. This is partly due to our neglect of means for enlarging and cheapening product, such as the hydraulic forging machine, and it is partly due to the want, in most of our steel works, of the more common trains and shaping machinery for making these various products. It can hardly be unjust to the commercial managers of our iron and steel works to express the belief that the technical managers are not chiefly responsible for this state of things, and that the cost of preparation for these enlarged manufactures cannot be pleaded as a complete excuse for their neglect.

3. The more important directions of improvement would appear to be:

a. In the Bessemer manufacture, the obtaining, by one or more of the means mentioned, of uniform iron of proper character to be used directly from the blast-furnace. The cheaper production also of such metals as manganese and chromium seems destined to largely improve the manufacture. As to the elimination of phosphorus and the better removal of other impurities in the converter, it can only be said that the study of change of affinities at different temperatures, which is now the subject of such important investigation upon puddling, is the only obvious road to improvement.

b. The open-hearth process seems to offer a fine field for development in many directions, chiefly in the production of steel castings for ordnance and large machinery generally, and in the manufacture of fine steels out of materials purified by direct preliminary processes. The open-hearth plant very much needs, what it should seem that suitable experiment and study may provide,—such arrangement and appliances as will largely save labour, and also better refractory materials; in the latter direction the use of water-pipes or jackets as a protection for exposed parts seems most promising.

c. The direct-ore processes do not yet show much evidence of competing with mechanical puddling for the production of wrought-iron; but they give promise of producing a cheap, pure, and economically usable material for open-hearth steel.

d. That mechanical puddling is rapidly revolutionising the wrought-iron manufacture cannot now be doubted. So many attempts at improving it are, however, still in the stage of partial experiment, that the direction of development cannot be definitely foreseen. Now that water-jacketing and various mechanical improvements are steadily leading to larger-sized furnaces and more regular output, it should seem that machinery for cheaply and powerfully compressing large balls should be one of the first directions of improvement. The notable removal of phosphorus by means of oxides and active mechanical agitation at low temperatures has lately been so well established as a chemical result that it offers a challenge to mechanical engineers with regard to cheap means for carrying it out.

e. The handling and rolling of heavy masses, such as ingots, by means of large trains and mechanical tables, has been well carried out by two different systems, which are both likely to be further improved. The cheaper and quicker handling by machinery, at the train, of such things as rails, beams, and plates, is the most obvious and important direction of improvement, unless the adaptation of the continuous mill to such products at once revolutionises the whole system of rolling, which it theoretically seems quite capable of doing.

Increasingly remarkable as has been the progress of iron metallurgy throughout the succeeding decades of the century, and stupendous as has been its advance, commercially and technically, during the last fifteen years, its horizon appears to be still extending; its possibilities are greater than ever before; they hold out a higher reward to the capitalist no less than to the chemist and to the engineer. Although the present supply of products may equal or even exceed the present demand, every department of the manufacture seems on the verge of a development which must largely cheapen the production, extend the uses, and increase the consumption of iron and steel.

COALS.

By Frederick Prime, Jr.

The representation of the coal deposits at the Centennial Exhibition in Philadelphia was a very unequal one. It was to be expected that foreign countries would send few or no exhibits of this class; and while visitors were agreeably surprised in seeing the beautiful series displayed from the Dominion of Canada, they were much disappointed at the entire lack of specimens from many of the most important districts of the United States. The coals to be described may be classified under the three great divisions of anthracite, bituminous coal, and lignite.

I. Anthracite.

Pennsylvania, which contains such important deposits of this class, was very inadequately represented, and the specimens shown, though in some cases very fine, still gave a very imperfect idea of the important industry which they represented.

Anthracite coal is a domestic fuel of very great importance to a large portion of the United States, being admirably adapted for use in the range and furnace, owing to its freedom from smoke and ash, and its high percentage of carbon, combined with great heating power. It usually contains from 85 to 92 per cent. of pure carbon, and about 7 to 11 per cent. of ash and volatile matter.

"When exposed to a high temperature, anthracite coal decrepitates, but this does not interfere with any of the uses to which it is applicable, nor is the coal subjected to any treatment preparatory to its being used for heating or smelting purposes. Anthracite produces a flame only when the carbonic oxide at first formed by combustion in an insufficient supply of air is brought in contact with more air and burnt to carbonic acid. Anthracite is usually divided into white-ash and red-ash coal; the former comprising the harder, and the latter the softer varieties. Preference is usually given to the white-ash coals for smelting purposes, as being harder and capable of carrying the greatest weight of ore and flux, and at the same time giving the greatest intensity of heat, which latter is necessary to ensure proper fluidity of the mass charged into a blast-furnace. Red-ash coals contain a little ferric oxide, which imparts a red colour to the ash. They are more easily kindled and burn more freely than the white-ash coals, but are more liable to form a clinker. For this reason they are not so well adapted to purposes which require a strong draft. Their especial adaptation is for the production of steam in large flue or cylindrical boilers and general household use. For steam purposes, the essential for tubular or high-draft boilers is the non-formation of clinker, and for low-draft boilers and household use, heat of great volume with absence of a large percentage of ash. For tubular boilers a moderate percentage of (not over 15 per cent.) voluminous pulverulent ash is of great advantage. Such an ash is to a great extent conveyed from the furnace by the draft, and carries with it a large amount of heat, which it gives out by contact with the flues much more efficiently than do the hot gases." Its value as a domestic fuel being so extended, it is carried great distances to be used for these purposes.

The anthracite region of Pennsylvania is usually divided into three parts, called respectively the first, second, and third coal-fields. The whole is situated in the counties of Luzerne, Carbon, Schuylkill, Northumberland, Dauphin, and Columbia.

The coal-measures within this region are almost universally surrounded by two mountain ridges, the exterior one of which consists of the sub-carboniferous sandstone, called vespertine by the Pennsylvania geologists. This is separated from the interior ridge by a more or less narrow valley of easily decomposing red shale, overlying which occurs the true conglomerate, holding in its bosom the valleys in which the anthracite is found. These two series of ridges were the efficient protectors of the coal from the denuding agents which removed it from the present intervening barren districts, which separate the different anthracite basins from each other and from the bituminous coal-fields of Central Pennsylvania.

From the first, southern, or Schuylkill coal-field, the only representatives were Cooper, Hewitt, & Co., and the Hickory Coal Company.

Cooper, Hewitt, & Co. exhibited but a single lump of coal, from their colliery at New Philadelphia. They work two of the upper red-ash seams, which are more especially adapted for steam-producing and household use, as they burn freely and rapidly and with more flame than the white-ash coals.

The exhibit of the Hickory Coal Company was a handsome one, consisting of a large block of coal weighing about eight tons, and of lumps of coal of various sizes, broken for domestic use. They sell their coal chiefly for the purpose just stated, and for raising steam.

It is much to be regretted that of the collieries, about eighty in number, actively engaged in exploiting this basin, the above named should have been the only exhibitors.

The coals of this field vary much in character, in passing from the east to the west. In the extreme western portion of the field, the coals assume much more the characteristics of a semi-anthracite, being richer in hydrogenous gases, burning with far more flame, and even, at times, semi-caking together. So that while the anthracite from the eastern portion of the field is much sought after for iron-smelting purposes, that in the middle and western portion is better adapted for steam-raising and domestic use.

The second, or middle coal-field, really consists of the larger Shamokin and Mahanoy basins, and numerous smaller ones, known as the Lehigh basins. It lies about ten miles from and nearly parallel to the first coal-field.

There were but two exhibits from the most western, or Shamokin basin, which were made by the Excelsior Coal Company, of Excelsior, Northumberland County, and the Reading Coal & Iron Company. The exhibit of the former consisted of the various sizes of coal they send to market, which seemed to be exclusively for domestic use.

The Reading Coal & Iron Company exhibited coal from the Locust Spring Colliery, taken out of the Mammoth bed, here 17 feet thick. They gave numerous analyses of the different branches, from which the following are selected:

I. Average of whole bed. II. Average, including top bench.

	I.	II.
Moisture	1·29	1·24
Volatile combustible matter	3·40	2·14
Fixed carbon	89·65	91·45
Ash	5·34	4·98
Sulphur	0·32	0·19
	100·00	100·00

The exhibitors from the Mahanoy basin were Theodore Garretson, of the Girard Colliery; the Hickory Coal Company, at Gilberton; and the Reading Coal & Iron Company. The former exhibited a lump of coal weighing about three tons, as well as specimens of prepared coal; while the Hickory Coal Company exhibited a block weighing 14 tons 13 cwt., and specimens of coal prepared for domestic use.

The display of the Reading Coal & Iron Company was a very fine one. It exhibited a fine shaft of coal in the Government Building, 44 feet high, showing the total thickness of the Mammoth bed at the Plank Ridge Colliery, of which 40 feet 11 inches are good coal, 1 foot 8 inches bony coal, and the rest interbedded slate. It also exhibited specimens of all the beds of coal which occur in this basin, viz.:

I.	Little Tracy	Bed,	4	feet	6	inches	thick;	from	Ellangowan	Colliery.
II.	Big Tracy	„	7	„	2	„	„	„	„	„
III.	Diamond	„	11	„	6	„	„	„	„	„
IV.	Orchard	„	8	„	10	„	„	„	„	„
V.	Primrose	„	13	„	9	„	„	„	Knickerbocker	„
VI.	Mammoth	„	37	„	6	„	„	„	Ellangowan	„
VII.	Skidmore	„	4	„	0	„	„	„	North Mahanoy	„
VIII.	Seven-Foot	„	7	„	0	„	„	„	„	„
IX.	Buck Mountain	„	13	„	0	„	„	„	West Shenandoah Colliery.	

Analyses of these coals furnished by the company gave the following result:—

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Moisture - -	1·960	1·500	1·480	1·920	1·440	1·350	1·200	1·250	1·020
Volatile combustible matter -	3·240	3·600	3·220	3·480	1·460	0·530	2·640	1·410	2·970
Fixed carbon -	86·372	83·619	85·316	88·032	93·502	96·199	89·576	90·986	88·147
Ash - - -	8·300	11·250	9·700	6·330	3·360	1·900	6·250	6·020	7·200
Sulphur - -	0·128	0·031	0·284	0·238	0·238	0·021	0·334	0·334	0·663
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Lbs. of water evaporated by 1 lb. coal - -	11·12	11·70	8·82	10·34	11·00	10·36	10·60	10·40	10·10

These coals, while very well adapted for domestic purposes, are also employed for cupola and foundry use; but it is a matter still somewhat in dispute, whether these coals are as well adapted for the latter purposes as those from the Lehigh basins or the eastern portion of the Schuylkill coal-field.

The Hazleton basin—the largest of the Lehigh basins—was represented by a shaft of coal, from A. Pardee & Co.'s lands, showing the thickness of the Mammoth bed at this point. It was 31 feet high, and formed a striking object at the Exhibition.

From the Black Creek basin there were two exhibitors, Van Wickle, Stout, & Co., who exhibited specimens of lump and prepared coal from Ebervale; and the Harleigh Coal Company, of Harleigh, who exhibited a lump of anthracite, weighing 8 tons, as well as a case of various sizes of prepared coals.

The coal from the various Lehigh basins is much esteemed for the blast-furnace, as well as for foundry and domestic use. The coal from the Mammoth bed is especially sought after for the blast-furnaces. It is this coal, combined with the limonite ores from the Great Valley and the magnetic ores from New Jersey, which have given the high reputation to the pig-iron produced in the Lehigh Valley. It is much to be regretted that of the many collieries situated in the various basins of the second coal-field, so few should have been represented. Still greater is the regret with respect to the Wyoming basin, from which there was not a single exhibit.

In mining anthracite it is divided into the following sizes, viz., Lump, Steamer, Broken, Egg, Stove, Chestnut, and Pea Coal.

The brittle nature of anthracite occasions a very large amount of waste in mining the coal. The character of the material from which the waste is formed is such as to give us a mixture of fine anthracite too small to be merchantable, earthy matter, slate, and rock. Until recently, little or no attempt has been made to utilise this waste, and the result has been the accumulation of enormous heaps of useless material near the opening of each mine. Some of these heaps have been accumulating many years, ever since the commencement of anthracite mining; and, as they have been exposed to atmospheric action, their value for heating purposes has been diminished. Besides which, in dealing with these masses as fuel, it has become necessary to overcome the difficulties incident to their containing all the elements for the ready production of ash and clinker, and their incapacity for producing an active fire on the ordinary grate.

In order to utilise this material, it is necessary either to consume it on a grate as it is, or else to employ some process that shall give a product of a size convenient for use. In either case care must be taken to prevent as far as possible the formation of large masses of clinker, as well as to dispose of the ash. The first of these two methods requires a grate of peculiar construction, which shall at once retain and consume the fuel, while peculiar appliances are made use of to insure the passage of the air through the fire-

bed, as well as its proper contact with the fuel. This is the method proposed by Mr. John E. Wooten, but not represented at the Exhibition. The second method was represented by three exhibits, viz., those of the Loiseau Pressed Fuel Company, of Jotham Newton, and of the Anthracite Fuel Company.

The Loiseau Pressed Fuel Company made its exhibit in a separate pavilion, close to Machinery Hall, where it showed the fuel burning in grates. The fuel, as prepared, is about the size of a small hen's egg, and rather resembles it in shape, the weight of each lump being two and a half ounces. This company claims to be the first which has manufactured artificial fuel, for domestic use, from coal-waste by mechanical processes on a commercial scale. The method adopted for the manufacture of this fuel is the following: the anthracite coal-dust is dumped on a covered platform, under which is a screen having a one-inch mesh. This screen receives a rapid back-and-forth motion, and screens the coal, delivering the dust under a chain elevator, which raises and discharges it into a bin. The potter's clay, which is used, is dried in an oven, and then ground in a Baugh grinding-mill, and delivered in a powdered state in a pocket alongside of the coal-bin. In the same room is an iron tank 6 feet high and 6 feet in diameter, in which is prepared a composition of lime, rye flour, and water, which is discharged in a liquid state into a wooden reservoir placed under the coal and clay bins. In front of these pockets is a distributer, by means of which 95 per cent. of coal-dust and 5 per cent. of clay are continually and mechanically taken out of the bins, delivered under a chain elevator, and there sprinkled through a perforated pipe with the liquid from the wooden tank. All the materials which are to form the fuel, having been thus brought together, are carried by the elevator to the mixing-machine. This machine has a capacity of six tons, and it delivers through two openings at the bottom, regulated by hand-wheels, the materials, on a leather belt, three feet wide, which carries and discharges them into the hopper of the press, between two rollers. On the faces of these are milled out semi-oval cavities, connected by small channels. They mould the fuel into the shape of eggs, and deliver it on to an endless wire-cloth belt, which enters the drying oven on top. In this oven, which is built of brick, 86 feet long, 14 feet wide, and 26 feet high, there are five endless wire-cloth belts, geared together, and travelling in opposite directions. This oven is heated, by a fire at each end, to a temperature of 250° to 300° Fah. The fuel, entering at the top, travels five times the length of the oven, at a speed of 12 feet per minute, falling from one belt to another, and finally coming out perfectly dry on the lowest belt, which enters the water-proofing building. In this building the lumps of fuel are discharged into a tank containing rosin or paraffine dissolved in crude benzine. In the same tank travels a wire-cloth belt, on which the lumps are discharged from the lower belt which comes from the oven. In this manner the lumps of fuel are immersed in the water-proofing liquid while the belt curves into the tank, and the same lumps are then carried into the evaporating oven, where all the vapours of benzine are collected, and carried through large pipes into a long condensing coil. The benzine, thus condensed, returns to the tank, while the coal, perfectly dried, is ready for market. The capacity of the present works, erected at Port Richmond, in Philadelphia, is stated by the company to be 100 tons per day. The fuel, as seen at the Exhibition, burned well, leaving, of course, the residuum of clay as ash, together with any solid impurities which the coal might possibly contain.

Jotham Newton, of New York City, exhibited specimens of fuel prepared under his patents. The specimens, cup-shaped, were a mixture of anthracite slack with some bituminous substance. In answer to inquiries addressed him, Mr. Newton said his process was the following: Anthracite coal-dust is mixed with coal-tar or asphaltum, or a mixture of both, to an extent sufficient to render the mass pasty, after which it is pressed into any shape desired. It is then retorted at a very low red heat. The retort must be so arranged as to admit a small amount of air at the commencement of the operation in order to induce combustion, which is, of course, at the expense of a portion of the coal. This is nothing more than applying the principle of charcoal-burning, where combustion is produced at the expense of the wood. As the walls of the retort have become hot, much less air is required in the charges subsequent to the first, consequently less coal is consumed. When gas ceases

to be evolved the operation is completed, and the charge can be drawn. The object of retorting is twofold: First, to distil over all volatile products, including the coal-tar. This last is condensed and saved for further use, except about 2·5 per cent., which remains behind in the fuel as a fixed residue, forming a binding medium for the coal, and giving the retorted mass a firm body. Second, to expel sulphur, and thus produce a refined coal. The patent calls for the addition of silica, potash, and alumina, about 2 per cent.; but for what object it is somewhat difficult to understand, as these substances would only render the fuel more impure, and of course reduce its heating power. In practice, the patentee claims that it is generally unnecessary to add them, as they are present in the coal in sufficient quantities.

The product, as exhibited, was a coarse coal-slack, cemented as just described. But while the patentee claims that it is a firm, compact mass, capable of being handled in any manner, this was not altogether sustained by experiments made by the writer of this article. The product seemed too friable to stand much handling without particles of the coal wearing off from the lumps in considerable quantities; nor is it a fuel that will stand much poking in the fire, for, while the main portion of the lump adheres together, the exterior portions drop off on stirring. The fuel, however, burns freely, without any smoke or sulphurous fumes, and, if left untouched, retains its form until entirely consumed. This fuel possesses one advantage over the Loiseau process, viz., that it contains less ash, if properly prepared, but, on the other hand, it seems to be more friable. This fuel has not as yet been produced on a manufacturing scale.

The Anthracite Fuel Company, of Rondout, New York, exhibited fuel manufactured under the Endres patents of 1875 and 1876. It is prepared by combining anthracite culm with the bitumen of coal-tar, or, as commercially termed "fuel-pitch." The works are located at Port Ewen, one mile below Rondout, on the Hudson River. Canal-boats, which convey the anthracite culm from the mines, are brought under an elevator, which has a discharging capacity of 30 tons per hour, and the culm is discharged and distributed to two receivers of 260 tons capacity each. Thence it is automatically fed to the conveyers, whence it goes to the dry mixers, where it meets the pitch. Here the two are mixed in the proportions of 10 parts of fuel-pitch with 100 parts of anthracite culm. The pitch has to be first prepared for mixing. For this purpose, between the two culm receivers there is erected a pitch receiver of 140 tons capacity, from the bottom of which the pitch drops into a crusher, composed, first, of a pair of heavy rollers with prismatic teeth, below which is a pair of supplementary rollers, with corrugated faces, for still finer reduction. The peculiar consistency of the material requires that it shall be knocked to pieces by concussion instead of being crushed by ordinary impinging surfaces. From the bottom of the crusher-pit the pitch is elevated and distributed to two smaller receivers, from whence, by an automatic feeder, it is fed in exact proportion to the culm moving, no matter what the speed of the latter may be. After the culm and pitch have been mixed, the material is carried to the fusing cylinder, where superheated steam is applied, causing a rapid melting of the fuel-pitch, and the mass then passes at once to the moulding-tables. In passing through these it is subjected to a pressure of 60,000 pounds, and comes out in rectangular bricks, weighing about 15 pounds each, which are delivered on the web of an endless chain, by which they are conveyed to boats, ready for use. The plant, which includes two machines, each with a capacity of 100 tons every ten hours, is entirely automatic. It is said that a ton of culm can, in ten minutes after leaving the canal-boat, be changed into solid blocks of coal ready for shipment. The motive-power of the works is a 200 horse-power Corliss engine, supplied by two McEntee & Dilton's tubular boilers, 6 by 16, 100 horse-power each. The company commenced operations in January 1876, and the production for the season of 1876, while the canal was open, is said to have been 25,000 tons. The use of this fuel has thus far been confined entirely to locomotive steaming purposes, and will probably be confined to this. It cannot compete with lump anthracite, at the present low price of the latter, save in exceptional cases. It is said, however, to be a steaming coal of uniformly high average, and well

adapted to the combustion of bituminous-burning engines, so that several roads have preferred it to soft coal, as being cheaper and better. During 1876 it was supplied to six railroads in New York and Connecticut. The reports of the roads using it praise the fuel for its high steaming quality and freedom from impurity and clinker. As to relative performance and economy, the data would seem to indicate all the way from 12 per cent. below to 5 per cent. above the average of bituminous and anthracite coals used for the same purpose. The Ulster & Delaware Railroad reported on four months' cost of fuel for 1876 a saving of 5 per cent. over the same period in the previous year, during which time, however, they had been burning anthracite at inflated prices. This road has severe grades, and prefers this patent fuel to lump anthracite, because it can haul equal loads and make its time without failure.

The Connecticut Western Railroad, on a careful comparison of 130 tons, reported that this fuel accomplishes about 10 per cent. less than Cumberland coal.

Mr. J. M. Toucey, Superintendent of the Hudson River Railroad, made a careful comparison, in May and June 1876, between anthracite fuel and coke in the Grand Central depôt engines, resulting in a consumption of 88,500 pounds of coke against 74,800 pounds of fuel. The price of the two is said to have been such as to make the economy in favour of the latter equal to 15 per cent.

Mr. R. C. Blackall, Superintendent of Machinery of Delaware and Hudson Railroads, made a comparative test, in August 1876, with the same engine, on the Rutland & Washington Branch of the Rensselaer & Saratoga Railroad. Result: 756 miles run; consumption of bituminous coal, 18,050 pounds, 97 miles per ton; anthracite fuel used, 18,300 pounds, 94 miles per ton.

A recent trial was made of this fuel on the Western Division of the Boston & Albany Railroad, with the following result:—Regular freight train from East Albany to Pittsfield and return,—anthracite fuel used, 7,502 pounds; average of Cumberland coal (best quality) used for five days previous, same service, 7,800 pounds.

This fuel is, so far as the writer of this report can ascertain, the only fuel which has been introduced into practical use in this country. There is nothing new in the process, it having been long since introduced into Europe. The only advantages that this company possess lie in the mechanical details of preparing and handling, which are much simpler and more economical than those used elsewhere. In conclusion, it may be stated, with respect to all the fuels prepared from anthracite culm, that their economical manufacture is based on obtaining the fine coal from the mines either for nothing or else at a very low price per ton. But it must be remembered that just as soon as a demand for this sort of fuel arises so soon does it have a value, and that as quickly as this value touches a certain point it then becomes impossible for the artificial fuels to compete with the lump anthracite. Nor can they do this even when the culm is obtained for a mere song when the price of anthracite is very low. Consequently, it is very probable that the manufacture of these artificial fuels will for many years be limited, both as to quality and the purposes for which they are used.

The Mining Department of Russia exhibited a series of anthracite coal from the Government of Ekaterinoslaw, which is situated just north of the Sea of Azof. This series was taken from the following localities:—

I. Anthracite from the estate of Mr. Bulazel.

II. Anthracite from the left bank of the river Cundrutchja; bed 2 feet 4 inches thick.

III. Anthracite from the ravine Shirokaja, on the river Krinka, near the village of Charziskaja; bed 4 feet 1 inch thick.

IV. Anthracite from the ravine Philipowa, near the village of Tchistjakowa; bed 4 feet 1 inch thick.

V. Anthracite from the ravine Perwi Iar, on the river Olchowaja, near the village of Oolawa; bed 4 feet 1 inch thick.

VI. Anthracite from the ravine Pogorelaja, on the river Sowostjanka; bed 2 feet 11 inches thick.

VII. Anthracite from the ravine Wodjanaja, on the river Chrustalnaja near the village of Chrustalnaja; bed 2 feet 4 inches thick.

VIII. Anthracite near the village of Malokrepinskoi; bed 3 feet 6 inches thick.

IX. Anthracite from the ravine Libimaja, near the village of Rowenec; bed 4 feet 1 inch thick.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Volatile matter -	—	8·12	5·84	7·67	7·86	5·73	7·76	6·61	5·42
Fixed carbon -	—	86·68	91·91	88·89	89·22	91·73	90·13	88·93	90·39
Ash - - -	—	5·20	2·25	3·44	2·92	3·53	2·11	4·46	4·19
	—	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Sulphur - -	—	—	2·89	1·297	2·52	1·50	1·06	0·984	1·09

In the Japanese Catalogue it is stated that a sort of coal occurs on the west side of Kiushiu which is very much like anthracite; also, that the coal found in Kii and Owari is of a similar kind.

II. Bituminous.

Bituminous coal is usually divided into bituminous and semi-bituminous, caking or coking, open burning or splint coal, and cannel. Bituminous coal includes all varieties of true stone-coal which contain more than 20 per cent. of volatile combustible ingredients; semi-bituminous, all those (excluding anthracites) which contain less than this amount. Caking or coking coal comprises those varieties which cohere and form a solid mass on exposure to heat,—as it were, semi-fusing together. Open burning or splint coal (sometimes called block coal from its breaking in cubes) includes all those varieties which do not cohere on exposure to heat, but gradually diminish and disappear on combustion without losing their original shape.

Cannel coal is a variety which usually has a more distinctly laminated structure than ordinary bituminous coal, and it has a finer and more compact texture. It is characterised by greater homogeneity in physical structure and chemical composition, and has a more laminated fracture, which is conchoidal across the planes of stratification in pure specimens. It contains more earthy and more volatile combustible matter, less carbon, and evolves gases having a higher illuminating power.

Canada.

The exhibit from the Dominion of Canada was from the island of Cape Breton, Pictou, and Cumberland. It was a very fine one, consisting for the most part of columns of coal, showing the thickness of the seams, and was only equalled by the display from West Virginia.

The coals from Cape Breton were exclusively from the eastern, or Sydney, coal-field. This is divided into several small basins, the chief of which are those at Sydney, at Glace Bay, and at Cow Bay. These three basins, more especially the two latter, vividly call to mind the prows of vessels which have been driven ashore; they form, indeed, the western extremities of the coal-field which extends under the Atlantic and terminates on the western coast of Newfoundland.

The exhibitors from the Sydney basin were R. H. Brown, General Manager of the Sydney Mines, and J. W. Fraser, of the Victoria Mine.

The coal from the Sydney Mines is chiefly used for domestic purposes; it contains a great deal of sulphur in the form of pyrite, which unfits it for many purposes; it is very inferior in quality to the coals which occur south of Sydney Harbour.

The Victoria Mine is worked on a seam which, while 6 feet 10 inches thick, yields five and a half feet of good clean coal. The mine was established to

work a submarine area on the east side of Sydney Harbour. The quality of the coal is very good, and it is chiefly used for domestic and steam purposes, not being considered fit for gas. The coal leaves but little ash, and the slack is excellent for blacksmiths' use.

The coals from Glace Bay were represented by exhibits from the Big Glace Bay, Caledonia, Little Glace Bay, International, and Gardiner Mines. They are far superior in quality to those obtained north of Sydney Harbour. The coal from the International Mine is chiefly used for the manufacture of gas, being exported for that purpose to the northern parts of the United States. It is said to be unusually hard, compact, and free from sulphur and shale, and to improve in quality as the mine is worked deeper. Hitherto it has been worked too near the outcrop. It is stated to be also a good steam coal, making a hot fire, and is certified to being equal to the best West Hartley coal (North of England). It possesses, however, the serious disadvantage that the clinker is very apt to adhere to the grate-bars.

At the Little Glace Bay Mine two coal-beds are worked, called the Hub and Harbour seams. The first of these, which is the uppermost, is 10 feet thick, eight feet of which are good, workable coal; it is especially adapted for gas purposes, contains a very small proportion of ash, and makes an excellent coke, while the slack coal is much esteemed by blacksmiths. The Harbour seam is $5\frac{1}{2}$ feet thick, and contains more ash than the Hub. The coal from both lights quickly, raises steam fast, and burns well; it produces a very moderate percentage of ash and clinker. While burning, these coals generate a great deal of smoke, the Hub seam somewhat less than the other; but the deposit of soot by both kinds is considerable.

The coal extracted from the Caledonia Mine is from the Phelan bed, which averages 8 feet 3 inches in thickness; but the top bench of eighteen inches, being of inferior quality, is not taken out. The proportion of ash is in excess of most of the Cape Breton coals, which renders it of inferior value as a steam coal; it is chiefly used for gas purposes, for which it is well adapted.

The Gardiner Mine extracts its coal from the Gardiner bed, which contains 4 feet 9 inches of uniformly good coal; the mine has been opened rather recently, and it has been impossible for the writer of this report to obtain trustworthy information as to the quality and character of the coal.

From Cow Bay, exhibits were made by the Blockhouse Mining Company and by the Gowrie Mining Company. The former of these is one of the most valuable and important mines in the Sydney coal-field, and has been, next to the Sydney Mines, the most productive. The bed worked is the Blockhouse seam, which is 9 feet thick, 14 inches of which are left untouched in the top bench. It yields a very fine homogeneous coal, free from partings, and yielding but a moderate proportion of ash; it contains, however, like all the others, a good deal of iron pyrites. It is almost exclusively used for the manufacture of gas, but is, at the same time, an excellent steam coal.

The Gowrie Mining Company work the McAuley bed, which is 5 feet thick, the top four inches of which, being very inferior, are left in the roof. Owing to the high proportion of sulphur it contains, it forms an inferior gas coal, and contains almost too high a proportion of ash to be well adapted for steam purposes. On the other hand it possesses the advantage of not forming clinkers.

All of the coals which occur in the Sydney coal-field are coking coals; they are rather high in sulphur, and those occurring at Glace and Cow Bays are chiefly used for gas purposes. The average analyses of the coals from this field show them to contain:—

Volatile matter	33·481
Fixed carbon	61·873
Ash	4·223
Sulphur	2·39
The specific gravity	1·316

They yield 9,340 cubic feet of gas per ton, and one pound of coal will evaporate 8·33 pounds of water. These coals seem to vary but little in

quality in the different beds, and while they are all used for general purposes, those obtained from certain of the seams are much valued for gas manufacture, being fully the equal of the Westmoreland coals of Pennsylvania. For steam purposes the Sydney coals are inferior to the Welsh and about equal to those of Newcastle, according to Professor How's experiments; their great defect is the high proportion of sulphur they contain, which makes them unfit, without previous washing, for iron-smelting, and renders them inferior to many other coals for domestic use.

To the north of Sydney Harbour lies the Great Bras d'Or, on the north side of which occurs the Cape Dauphin coal-basin. This is the northern extremity of the Sydney coal-field. C. J. Campbell, Esq., who has operated the new Campbellton Mines, exhibited coals from them. The appearance of the coal was good, but the writer of this report did not succeed in obtaining facts as to its quality.

The exhibits from the Pictou coal-field were by the Intercolonial Mining Association, the Acadia Coal Company, and the General Mining Association.

The Intercolonial Mining Association exhibited a block of coal from their Drummond Colliery, the Acadia Coal Company had blocks from the Acadia Mines, and the General Mining Association, coal and coke from the Albion Mine.

While some of the mines furnish a good quality of coke, the coal from other pits either yields but a poor quality of coke or will not coke at all. The coal is much freer from sulphur than the Cape Breton coals, but, on the other hand, it contains much less carbon and a very high percentage of ash. It is better adapted for iron smelting and rolling-mill purposes, as it is found to form but little clinker, and that does not cling to the grate-bars; but it is inferior to the Cape Breton coals as a gas coal and for steam purposes.

The coal-beds of this district are much thicker than those of the Sydney coal-field. Two of the beds at the Albion Mines are respectively 23 and 35 feet thick. From the Spring Hill coal-field, in Cumberland County, a column of coal was sent by the Spring Hill Mining Company. The coal, from its analysis, appears to belong to the fat, caking class. Owing to the high percentage of volatile ingredients it contains it should be a good gas coal, while the amount of sulphur is low. As yet the extent and value of this coal-field are but imperfectly known.

United States.

Passing to the United States, we come first of all to the great Appalachian coal-field, which covers 58,265 square miles, and extends from Pennsylvania and Ohio, through Maryland, West Virginia, Eastern Kentucky, and Tennessee, to Alabama. This is divided up into numerous small basins, sometimes closely united, again separated by greater or less intervals.

Pennsylvania.

The first coal district is the Broad Top field, which form an isolated coal region in Huntingdon, Bedford, and Fulton counties, Pennsylvania.

The lower coal series is well represented in this district, as well as the so-called "barren measures," which separate the upper and lower coal-series, while in Broad Top Mountain, near its summit, there remains a small patch of the Pittsburgh bed, which forms the base of the upper coal-series. This coal-field is small, and the coals which occur in it are highly esteemed for steam-raising purposes. It is also well adapted for smelting, and makes a good coke, although not equal to the celebrated Connellsville coke. The coal is said to be very free from sulphur, which, of course, exempts it from spontaneous combustion, and hence renders it a very valuable fuel for ocean steamships. The coal is usually called semi-bituminous, as being less rich in hydrocarbons than some of the coals from the more western portions of the Appalachian coal-field. The exhibits from this district were made by the Huntingdon and Broad Top Railroad Company, Robert Hare Powel & Co., and the Rockhill Iron and Coal Company, who all exhibited coal and coke.

An analysis of the coal from this coal-field, made for the Pennsylvania Railroad, gave the following result :—

Moisture	0·30
Volatile matter	17·55
Fixed carbon	74·65
Ash	7·50
	100·00

Passing westward, the first coals exhibited came from the first bituminous coal-basin of Pennsylvania. The exhibits were by the Cambria Iron Company, of coal and coke from Johnstown and Bennington, and Dysart & Co., from Sonman, in Cambria County; also by the Kittanning Coal Company, from their Franklin Colliery at Houtzdale, and by Robert Hare Powel & Co., from their Stirling and Powelton Collieries, near Osceola, Clearfield County. The coals from this district are used both in iron smelting and for steam-raising purposes. The coals exhibited by the Kittanning Coal Company and Robert Hare Powel & Co. come from the so-called steam-coal basin of Clearfield County. They belong to the semi-bituminous coals; they coke well, and contain between 21 and 23 per cent. of volatile hydrocarbons. Practically, however, the attempt to coke them on a commercial scale is not made, and the coal sold is used almost exclusively to generate steam in manufactories, locomotives, and ocean steamships, and enjoys a high reputation for this purpose. The coal also stands high in the estimation of blacksmiths, and is extensively used by them.

The coal mined in Clearfield County comes almost exclusively from coal "B" of the Pennsylvania Geological Survey, which is a bed from 4½ to 6 feet thick. Analyses made by the geological survey gave the following results :—

I. From the Franklin Colliery. II. From the Stirling Colliery.

	I.	II.
Moisture	0·670	0·710
Volatile matter	21·360	23·400
Fixed carbon	74·284	72·218
Sulphur	0·435	0·532
Ash	3·251	3·140
	100·000	100·000

There is no doubt that this coal, if coked, would be very well adapted to iron smelting. Sometimes the bed worked is said to carry streaks of pyrite, but in such a manner that it can be readily separated.

The Kittanning Coal Company showed two large blocks of their coal, one weighing 5½ and the other 2½ tons.

The coal and coke exhibited by the Cambria Iron Company is mined and prepared exclusively for their extensive iron-works at Johnstown. The coal is bituminous, of good quality, and, coked in Belgian ovens, yields a good coke, inferior in quality to the Connellsville, but still well adapted for iron smelting.

John Keys, of Brockwayville, exhibited a lump of coal, 8 feet long by 3 feet 3 inches high, from the Jefferson County gas-coal basin. This belongs to the fourth bituminous coal basin of Pennsylvania. The bed worked is 4 feet thick, including a two-inch slate parting. The coal is said to mine well, and contains a large quantity of hydro-carbons, as shown by the subjoined analysis made by the chemist of the State Geological Survey, but the large percentage of sulphur it contains, if the analysis is made from average samples of the coal, would render it objectionable both for gas purposes and for iron smelting, unless the coal is washed previous to coking it. The analysis gave—

Moisture	1·360
Volatile matter	38·720
Fixed carbon	53·683
Sulphur	2·047
Ash	4·190
	100·000

Passing down in a south-west direction along the axis of the fourth coal-basin, we come to the magnificent gas coals of Westmoreland and Fayette Counties, where the Pittsburgh bed, the lowest of the upper coal beds, is mined, and from which the celebrated coke known as Connellsville coke is made.

Exhibits of coal and coke were made by the Westmoreland Coal Company, the Penn Gas Coal Company, Stoner, Hitchman, & Co., Robert Hare Powel & Co., John M. Cochran & Co., and A. A. Hutchinson & Co.

The coal mined comes from the eastern margin of the coal field, and is mined from the Pittsburgh bed, which is 8 to 11 feet thick. Owing to its high percentage of hydrocarbons and freedom from sulphur, this coal enjoys a very high reputation for gas purposes. It also yields a high percentage of most excellent coke, which is unexcelled for iron smelting, owing to its quality and to its strength, which, as it does not crush easily, sustains a very heavy burden in the blast furnace. So high is the reputation of this coke that it is carried in boats from Pittsburgh down the Ohio to St. Louis, to be there used in the blast furnace. It is also found capitally adapted to the reduction of silver and lead ores, being carried for this purpose all the way to Utah. It is found to be well adapted for blacksmithing and for foundry purposes. An analysis of this coal made for the Pennsylvania Railroad gave—

Moisture	1·30
Volatile matter	30·41
Fixed carbon	61·45
Sulphur	1·04
Ash	5·80
	100·00

Frequently, however, the percentage of sulphur is still lower.

Ohio.

Passing over the State line, we come to the continuation of the Appalachian coal-field in Ohio.

A very fine collective exhibit of coals was made by the Mahoning Valley Centennial Association. The coals exhibited were from the following mines: Burnett, Long, No. 3, Stewart, McKinnie, Love, Osborn, Holliday, Sodom, Church Hill, Kline, No. 1, No. 2, Foster, Kyle, Powers, Lauterman, Packard, Foulk, Jacobs, Pennell, Harroff, Canfield, Brookfield, Shenango, Hamilton, Ashland, McKinney, Peacock, Morris, Cambria, Weathersfield, and Ohlton.

The coal from the Mahoning Valley is generally known as the Block or Brier Hill Coal, and enjoys a deservedly high reputation for iron-smelting purposes, being capitally adapted for the production of Bessemer pig-iron, owing to its freedom from sulphur. It forms the basis of the great iron-industry of Northern Ohio. The bed from which this coal is mined is "Coal Seam No. 1" of the Ohio Geological Survey, the lowest in the series of the coal measures. It is, unfortunately, very irregular in its distribution. It is used for iron smelting in a raw state, and is called "block coal" from its breaking into large blocks, which are of a very compact character. An analysis of this coal by the chemist of the State Geological Survey gives—

Moisture	2·47
Volatile combustible matter	31·83
Fixed carbon	64·25
Ash	1·45
	100·00
Sulphur	0·56

The Franklin Coal Company exhibited specimens from their mines in Summit County. The bed worked is the lowest, or No. 1; it is 4½ feet thick, and of good quality; it is a bright, handsome, open-burning coal,

apparently containing but little sulphur, if any, and is said to contain but a small percentage of ash. It is softer and more bituminous than the coal from the same bed in the Mahoning Valley, but is still capable of being used in the raw state in the furnace, and is much liked both for domestic and steam purposes. Owing to its inflammable character its combustion is not quite so easily regulated as that of the Mahoning Valley coal, and it takes a little more of it to smelt a ton of iron. It is claimed for this coal as a household fuel that those who use it prefer it to every other variety of coal, even to the best cannel. The chemist of the Ohio Geological Survey analysed the coal from the Franklin mines, and found it to contain—

Moisture	3·40
Volatile combustible matter	36·10
Fixed carbon	58·70
Ash	1·80
	100·00
Sulphur	0·799

Coal from the same bed in Stark County was exhibited by John G. Warwick, the Grove Coal Company, and J. P. Burton, of Massillon, and by the Wadsworth Coal Company, from Medina County. The coal from these mines is apparently identical with that just described from Summit County. It is generally more bituminous, breaking more irregularly, and having less of the block character than that of the Mahoning Valley.

Specimens of coal "No. 4," corresponding to the Pennsylvania "Kittanning" bed, were exhibited by the Cherry Valley Iron Company, from Leetonia, Columbiana County, and by the Newark Coal Company and the Licking Iron Company, from Flint Ridge, Licking County.

The coal from Leetonia seemed to be a very pure bituminous coal, and the coke exhibited made from it was very good. The coal is eminently distinguished as a coking coal, and the pig-iron exhibited as made from it looked soft. An analysis of this coal by the State Geological Survey gave—

Moisture	2·56
Volatile combustible matter	39·60
Fixed carbon	56·04
Ash	1·80
	100·00
Sulphur	0·53

The coal, where mined, is 2½ feet thick. The low percentage of ash and sulphur is very striking, and explains the good quality of the iron.

The coal from this same bed at Flint Ridge has entirely changed its character, being a cannel coal, and occurs in a bed four to six feet thick. The coal appears to be of a good quality; like most American cannels its percentage of ash is high, and the amount of sulphur considerable. An analysis of the Flint Ridge coal by the State Survey gave—

Moisture	2·60
Volatile combustible matter	40·20
Fixed carbon	44·00
Ash	13·20
	100·00
Sulphur	1·34

This coal was formerly mined for distillation into oil, but its principal use at present is for domestic purposes.

Coal was displayed by the Steubenville Coal and Mining Company from their mines at Steubenville. The coal is here mined by shafts sunk to reach it. The coal mined is the "No. 6" bed of the Ohio Geological Survey; it is here about four feet thick, and is a partially open-burning coal of great

excellence, and is used in all the ironworks at this point. It has been used considerably in the raw state in the blast-furnace, but is now generally coked. An analysis by the chemist of the Survey shows this coal to contain—

Moisture	1·40
Volatile combustible matter	30·90
Fixed carbon	65·90
Ash	1·80
	100·00
Sulphur	0·98

It will be seen that the ash and sulphur are low. The Glasgow and Port Washington Coal and Iron Company and the Tuscarawas Coal and Iron Company exhibited coal from the same bed, "No. 6," in Tuscarawas County. At Port Washington this coal is 7 feet thick. It is said to be a typical coking coal, which will make an excellent coke if washed. Without this, it is too high in sulphur to be well adapted for iron-smelting, as it contains between 2 and 3 per cent. of this impurity. The coal breaks irregularly, with broad, smooth, black, resinous surfaces, and is rather tender. The coke is bright and handsome if properly treated. The coal is much liked for steam purposes.

Coals from this same bed were exhibited by the Hurd Coal Company, Straitsville Mining Company, Peter Hayden, and W. B. Brooks and Son, all from the Hocking Valley. This bed, which is the equivalent of the Upper Freeport coal of the Pennsylvania geologists, is at this point of great importance, and has a thickness of 6 to 12 feet. It is here an open-burning coal, used without coking in the blast-furnace, often contains but a small amount of sulphur, and is also used in the manufacture of gas. Although not as highly bituminous as some other varieties, yet the flame is considerable. It has been used with great satisfaction in many of the Ohio rolling-mills; it is highly esteemed for the generation of steam, and is much liked for domestic use. "The small percentage of ash, the unusually complete combustion, giving a fine blaze and little smoke, the large percentage of fixed carbon, giving great heating power, and the small amount of sulphur, all combine to render the coal of this great seam one of the best-known coals for all uses." Analyses of this coal by the chemist of the State Survey gave the following results:

	I. From New Straitsville, Perry County.	II. From Nelsonville, Athens County.
	I.	II.
Moisture	6·90	5·95
Volatile combustible matter	30·25	32·38
Fixed carbon	58·19	57·12
Ash	4·66	4·55
	100·00	100·00
Sulphur	0·79	0·77

The value of this coal has recently been greatly enhanced, from the fact that iron can be made with the native ores as cheaply as in any part of the United States, while, the markets being near at hand, this district becomes a formidable competitor with those whose iron-manufacture is already established. It takes an average of three tons of this coal to make a ton of iron; but a great deal of it is unfitted for making iron on account of the large quantity of sulphur which it contains locally. The author of this report does not know whether it will pay to wash the coal, and thus purify it. It may be said, however, that there is an abundance of this coal which is practically free from sulphur, and is hence well adapted to iron-smelting.

Specimens of the "No. 7" coal-bed of the Ohio Survey were exhibited by the Ohio Coal Company, from Cambridge, Guernsey County, and E. A. Fitch, from Athens County. At Cambridge the coal is of the caking character, and yields a compact coke; the best combustion of the coal is produced by a strong

draft. The bed of coal is 5 feet thick. The coal is high in sulphur, which is mostly removed on coking it; unless this is removed the fuel would be unfit for iron-smelting. In Athens County the coal is about 4½ feet thick. It is fair in quality, and will probably answer for raising steam and household purposes; the coke from this coal is firm, and possesses great tenacity. Analyses of these coals have been made by the Geological Survey.

	I. From Cambridge, Guernsey County.	II. From Bayley's Run, Athens County.
	I.	II.
Moisture	3·00	4·75
Volatile combustible matter	34·15	34·90
Fixed carbon	57·39	54·95
Ash	5·46	5·40
	100·00	100·00
Sulphur	2·57	2·40

It is most probable that the "Sheridan" coal of the Hanging Rock iron district, in Ohio, belongs to this same bed. It was exhibited by the Hanging Rock Iron Association, which made a collective exhibit. The coals from this part of the State have been as yet but little exploited, and those opened are said not to be very good for iron-smelting. Although much of the coal is high in sulphur, yet this is not the case with all of them, and it is very possible that future explorations will show the existence of good coals.

Coal from the "No. 8," or Pittsburgh, bed was exhibited by the Pomeroy Coal Company from their mines at Pomeroy, Meigs County. The coal-bed at this point measures between 4½ and 6 feet in thickness, but it always has one or more partings. It is highly esteemed as a mill and steam coal, and for household purposes. It is not regarded desirable as a gas coal, and the percentage of sulphur shown in the analysis is below the average. It is at present not coked, and the coke might be too tender for iron-smelting, although there is no evidence on this point. From the analysis there is no reason to suppose it in any way inferior to the Youghiogheny coal, or that the coke would be inferior to the Connellsville. The analysis given by the State Geological Survey is as follows:

Moisture	4·10
Volatile combustible matter	33·90
Fixed carbon	56·10
Ash	5·90
	100·00
Sulphur	0·46

The coal yields a large percentage of gas.

Specimens of coal-bed "No. 10" were exhibited by the Ohio Coal Company from Macksburg, Washington County, at a point where the bed is 6 feet thick. The coal is said to be of good quality for domestic use and steam purposes, and also for rolling-mill purposes, and is a coal of good heating power.

West Virginia.

The exhibit of coals made by the State of West Virginia was a very fine one, only equalled by that made by the Dominion of Canada. Numerous large blocks of coal were erected on the grounds in close proximity to the State building, while many smaller specimens were exhibited in the interior of the latter. No State in the Union surpasses it in the variety of coals it contains, nor does any contain an equal amount in proportion to the area, for of the fifty-four counties in the State but six are entirely destitute of this important fuel. In many of them, however, the coal is so deeply buried and in others the means of transportation are so poor, that it will be many

years before the mineral wealth they contain will even commence to be developed.

The coal-field of West Virginia may be regarded as a continuation of that in Pennsylvania, and forms a portion of the Great Appalachian coal-field. The area of the West Virginia is estimated as being 16,000 square miles.

The first coal displayed came from the Potomac basin, which is a prolongation of the Maryland "Cumberland coal-field." The coal from this basin was exhibited by the Virginia Coal Company, from their mines at Piedmont, in Mineral County. The seam worked here is the Pittsburgh, which at this point is 14 feet thick, having a 1½-inch slate parting 4 feet from the floor. The entire thickness of the coal is mined. It is here semi-bituminous in character, having lost a portion of its volatile matter, and is therefore unfit for gas purposes. It is especially adapted for steam and blacksmiths' purposes, and is largely used by steamers. The following analyses are given by the State Centennial Commissioners :—

	I. Top coal.	II. Bottom coal.
	I.	II.
Moisture	0·82	0·50
Volatile combustible matter	19·36	17·51
Fixed carbon	75·86	79·01
Ash	3·96	2·98
	100·00	100·00
Sulphur	0·71	1·13

Next in order is the Preston County basin. Specimens of the "Upper Freeport" bed, which is worked here, were shown from the Austin Mine, as well as coke made from it. The coal-seam is here 8 to 9 feet thick, though only the lower bench, 4 feet thick, affords at all points a first-rate quality of coal. It is said that the whole thickness of the bed could be taken out and sold if the mining were carried on on a large scale. The coke exhibited was of a bright, silvery aspect, and is said to bear the heaviest burdens in the blast-furnace. Analyses given by the Commissioners of West Virginia are as follows :—

	I. Coal.	II. Coke.
	I.	II.
Moisture	0·11	0·54
Volatile combustible matter	31·12	—
Fixed carbon	66·29	87·55
Ash	2·48	11·26
	100·00	99·35
Sulphur	0·64	0·65

Specimens of the outcrop coal on the lands of the Kingwood Gas-Coal and Iron Company were also exhibited, and it is stated that the coke made from it is used satisfactorily in the blast-furnace. The bed is 4½ feet thick. Analyses of this coal were also given by the State Commissioners :—

	I. Top of bed.	II. Bottom of bed.
	I.	II.
Moisture	0·34	0·51
Volatile combustible matter	31·47	31·19
Fixed carbon	65·66	66·13
Ash	2·53	2·17
	100·00	100·00
Sulphur	0·58	0·01

The next basin is the Monongahela. The coal-measures are first met in Monongahela County. A fine exhibit of the series of rocks comprising these measures in this county was made by W. S. Willey. The coals exhibited

were from the Lower Freeport seam, which is 4½ feet thick where opened; the Pittsburgh bed, 11 feet thick, of which 9½ are clear coal; the Red-stone bed, 5 feet thick; the Sewickley bed, 6 feet thick; and the Waynesburg seam, 5 to 6 feet thick. The Pittsburgh seam is the only one worked to any extent, and here, as elsewhere through the State, it is a valuable gas coal, the only exception to this rule being in the Potomac basin, already mentioned. It ranks high as a gas coal throughout the United States, and yields a good, firm, solid coke. Analyses of the coals from this locality were furnished by the State Commissioners, as follows :—

I. Upper Freeport coal. IV. Sewickley bed.
II. Pittsburgh bed. V. Waynesburgh seam.
III. Redstone seam.

	I.	II.	III.	IV.	V.
Moisture	0·63	0·39	0·37	0·44	0·74
Volatile combustible matter	28·06	38·64	37·88	35·78	35·36
Fixed carbon	54·28	54·77	54·36	54·31	56·35
Ash	17·03	6·20	7·39	9·47	7·55
	100·00	100·00	100·00	100·00	100·00
Sulphur	0·77	2·54	2·87	3·10	0·71

The sulphur in all these coals, except the Upper Freeport and Waynesburg beds, is said to occur as sulphate of lime or magnesia, and not as pyrite.

Specimens of coal from the Pittsburgh seam were exhibited which were taken from the Gaston Mine, at Fairmount, in Marion County; also a specimen of the Redstone bed, taken from the land of R. S. Radcliffe, in the same county. The coal from the Gaston Mine has a high reputation for gas purposes, and also is a good generator of steam. The Pittsburgh seam is here 8 to 9 feet thick, and shows no partings. The percentage of sulphur is much higher than that from the Youghiogheny region in Pennsylvania, but is compensated for by the higher percentage of gas. The coke made from it is hard and tough, but the high percentage of sulphur it contains renders it unfit for blast-furnace use, even when mixed with Connellsville in the proportion of 2 to 1. The analysis of this coke, furnished by the State Commissioners, is as follows :—

Coke	67·5
Volatile matter	32·5
	100·0
Ash in coal	2·1
Sulphur in coal	0·95
„ coke	0·69
„ volatile matter	0·27

A gross ton of this coal is said to have a maximum production of 11,043 cubic feet of gas of 16 candle-power.

The Redstone seam is not exploited. The thickness of the bed at the point where the sample was taken was 6½ feet. The analyses gave :—

Moisture	1·01
Volatile combustible matter	40·96
Fixed carbon	50·33
Ash	7·70
	100·00
Sulphur in coal	4·27

It is a great pity that the high percentage of sulphur should render this coal comparatively valueless, as the amount of volatile matter which it contains is very high.

Two specimens of coal were exhibited from Taylor County,—one from the Pittsburgh bed, from the land of J. H. Barnes, the other, a cannel coal, from the lands of S. Carrothers, at Ironton. The former coal is worked by several companies, yields an excellent coke, and the coal bears a good reputation for gas purposes, although it contains considerable sulphur. The position of the cannel is below the former bed, its quality is inferior, and its position in the geological series has not been determined.

The exhibits of coal from Harrison County were all taken from the Pittsburgh bed, and were sent by the Despard Gas-Coal Company and the Murphy's Run coal-mine near Clarksburg, and Monongahela Gas-Coal Company at Wilsonburg. The coal is precisely like that mined in Marion County. The thickness of the bed at Clarksburg is about 9 feet, and at Wilsonburg 8 feet. It is divided by a clay parting, above which the coal is hard and below soft. The lowest foot of the bed is of too poor a quality to be sold. Sulphide of iron is present in large quantities, usually in lumps and easily separated. It is largely sold for gas and steam purposes. Containing more sulphur, it requires a larger percentage of lime to purify it in gas-making than the Pennsylvania Westmoreland coals, but it is claimed that this disadvantage is compensated by a larger yield of gas and a higher illuminating power. The analyses furnished by the State Commissioners gave:—

	I. Despard mines.	II. Murphy's Run mines.	
		I.	II.
Moisture		—	1·58
Volatile combustible matter		40·00	37·10
Fixed carbon		53·30	49·08
Ash		6·70	9·40
Sulphur		—	2·84
		100·00	100·00

One gross ton of No. I. yields 9,500 cubic feet of gas of 20·41 candle-power, and 1,541 pounds coke. No. II. yields 11,401 cubic feet of gas of 17·2 candle-power.

A specimen of bituminous coal was displayed from J. & D. Hudson's mines in Hancock County and another from the Stanton Rock Coal-works, in Brooke County, opposite Steubenville, Ohio. The former is taken from a bed 3 to 6 feet thick, and the latter from one 4 feet thick. It is most probable that they both came from the "No. 6" of the Ohio Geological Survey; if so, their composition is identical with that given of the Steubenville coal.

In Ohio County, the Pittsburgh bed is worked at and near Wheeling. It varies from 5 to 7¼ feet in thickness of which about 5 feet is worked. It is extensively used in rolling-mills and for steam purposes, but is unfit for use in iron-smelting and gas-works, owing to the large amount of sulphur which it contains. Mr. L. Hill exhibited a specimen from his mine at Wood's Run, four miles from Wheeling, where the bed is 7¼ feet thick. The Bogs Run Mining Company at Wheeling also had a specimen from a point where the seam is 6 feet thick. At the latter point it is extremely convenient for shipping, as the bed is worked at a place where it crops out 10 feet above the Baltimore & Ohio Railroad track. Analyses furnished by the Commissioners were as follows:

	I. Top bench, Wood' Run.	II. Bottom bench of same.	
		I.	II.
Moisture		1·74	1·52
Volatile combustible matter		42·97	38·44
Fixed carbon		50·99	47·77
Ash		4·30	12·26
		100·00	100·00
Sulphur in coal		2·88	3·82

The portion of West Virginia which is richest in mineral fuel is that on the New and Kanawha Rivers; this district is nowhere surpassed in the number and variety of its coal-basins, and only requires a larger population and better means of transportation to become one of the greatest manufacturing centres of the United States. The New River basin is of great importance, and is interesting as containing workable coal-beds in the conglomerate series underlying the true coal-measures.

In Raleigh County, the Quinnimont furnace is supplied with the coal from one of these beds 4 feet thick. The coke made from it as exhibited appears to be of an excellent quality, while the coal from which it is made is semi-bituminous. It is very soft and friable, and, in addition to being used for the manufacture of coke, it is said to be capitally adapted for steam-raising and domestic purposes, as it makes a very hot red fire. Analyses of the coal and coke made for the Quinnimont Furnace Company were:

I. The four-feet coal. III. Coked slack.
II. Coke from same. IV. G. H. Prince's coal.

	I.	II.	III.	IV.
Moisture	0·94	—	—	0·33
Volatile combustible matter	18·19	—	—	19·19
Fixed carbon	75·89	93·85	91·72	75·82
Ash	4·98	6·15	5·57	4·73
Sulphur	—	0·30	0·48	—
	100·00	100·30	97·77	100·00

Two other specimens of coal from Raleigh County, which closely resembled that from Quinnimont, were also exhibited,—one from a 6½ feet bed from J. R. Milligan's mine; the other from a 6 feet bed on the land of G. H. Prince. The analysis of this last, furnished by the State Commissioners, is given with that from Quinnimont. It contains 0·86 per cent. of sulphur in the coal. These samples probably came from the bed opened near Raleigh court-house, which belongs really to the vespertine (Catskill) formation, and lies below the conglomerate series in which the Quinnimont coal occurs. The coal is said to be very pure, and, as the bed occurs under the entire Raleigh plateau, will be a valuable seam for local purposes. Continuing down the New River basin, the next county is Fayette. Exhibits were made of coal and coke by the Coal Valley Coal Company, the Longdale Coal and Iron Company, the Nuttalburg Mine, the Gauley-Kanawha Coal Company, Dr. W. H. Letterman, and Beverley Cole. The bed worked by the Longdale Company is the first one above the great conglomerate, probably the "A" seam of the Pennsylvania and "No. 1" bed of the Ohio geologists. It is here 3½ feet thick, and is a soft and tender coal, making a very good coke used in the company's furnace in Alleghany County, Virginia. The coal and coke exhibited by the Nuttalburgh Mine probably comes from the same bed, as it closely resembles the exhibit just mentioned, and the bed is said to be 3½ to 4 feet thick. Both belong to the semi-bituminous class, and as usual the coal is tender and friable, pure in carbon, and in this locality rather high in volatile matter. The coke exhibited seemed to be of good quality. The Gauley-Kanawha Coal Company exhibited coal from their mines at Hawk's Nest, lower down the river, where they mine a bed 11 feet thick and having four partings in it. The coal is higher up in the coal formation than those just mentioned and is richer in gaseous matter; the character of the coal is hard and pure. A gross ton of it is said to give off 10,100 cubic feet of gas of 17·9 candle-power. The Coal Valley Coal Company exhibited a section of the bed worked by them 7 feet thick; of this the upper 16 inches is splint, the remainder gas coal. This latter is said to give 10·800 cubic feet of gas of 17 candle-power. The exhibits of Dr. Letterman and Mr. Cole were both from the so-called "Cotton Hill" bed, a local name, and of which the position

in the coal-series is not quite determined; the coal is bituminous in character. Analyses of the coals furnished by the State Commissioners gave:

I. Longdale Company's coal.
II. Coke from same.
III. Nuttalburgh coal
IV. Coke from same.
V. Coal from Gauley-Kanawha Company.
VI. Gas coal from Coal Valley Company.
VII. Splint coal from same.

	I.	II.	III.	IV.	V.	VI.	VII.
Moisture	1·03	—	0·34	0·32	1·30	1·32	0·18
Volatile combustible matter	21·38	—	20·59	—	31·93	35·21	38·32
Fixed carbon	72·32	93·00	69·00	91·22	64·60	61·60	57·20
Ash	5·27	6·73	1·07	7·53	2·11	1·87	4·30
Sulphur in coke	—	0·27	—	0·93	—	—	—
	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Sulphur in coal	0·27	—	0·78	—	5·74	0·66	1·21

Keeping down the river to where it runs into the Great Kanawha, we come to Kanawha County, in which the conglomerate entirely disappears from view, and all the mountains are composed of the lower coal-measures. The exhibits from this county were made by the Mill Creek Cannel Coal Company, the Kanawha Semi-Cannel Coal Company, the Enterprise Coal Company, J. D. Lewis, and W. M. Hovey.

The Kanawha Semi-Cannel Company exhibited specimens from six different beds, viz.: bituminous coal from the "Blacksburgh" seam, 3½ feet thick, a good gas coal, yielding 10,640 cubic feet of gas of 18 candle-power per ton; gas coal from the outcrop of a bed 3½ feet thick, having a 6 inch parting, claimed to be good for gas, steam and blacksmiths' purposes; cannel coal from an outcrop 28 inches thick; gas coal from the "Cedar Grove" bed, good for gas, blacksmiths', and steam purposes; bituminous coal from the "Coalburg" seam, 7 feet thick, with a 10-inch slate parting, good for domestic and steam purposes; and splint coal from the "Lewiston" bed, which is 4 feet thick, of an excellent quality for house and steam purposes. The Mill Creek Company exhibited a good specimen of cannel coal from a bed 5½ feet thick. J. D. Lewis exhibited splint coal from the Campbell's Creek bed 6 feet thick. The Enterprise Coal Company exhibited coal of the same character from their mines, taken from a bed of the same thickness. A specimen of cannel coal was exhibited from a mine on Falling Rock Creek, Elk River, also of good quality. The analysis of this coal gives:

Volatile matter	43·20
Fixed carbon	50·80
Ash	6·00
	100·00

This shows much less ash than most of the American cannels. A ton of this coal gave 13,400 cubic feet of gas of 25 candle-power. The Lewiston Coal Company exhibited bituminous coal from a bed 4 to 6 feet thick. W. M. Hovey exhibited specimens of splint coal fram Davis Creek.

Just over the county line and to the south of Charleston are the mines of the Peytona Cannel Coal Company, in Boone County. They exhibited a lump of coal showing the thickness of the bed they work, as well as other specimens. The analyses of this coal gave:

Volatile matter	46·00
Fixed carbon	41·00
Ash	13·00
	100·00

The maximum yield of gas per gross ton is 13,200 feet of 32·16 candle-power; while at a yield of 10,000 cubic feet it gives 41·16 candle-power. This coal,

and that mined by the Cannelton Coal Company in Kanawha County, are noted as gas "enrichers," being carried to far Eastern and Western cities, where they are mixed with inferior coals at the gas-works. They bring a higher price, on account of this property, than any other coal mined in the United States.

A specimen of cannel coal from the land of A. Ball, near the county court-house, was also displayed; the bed is said to be 5 feet thick, and the coal was apparently of good quality.

From Lincoln County, specimens of splint coal were exhibited from a 5-feet bed on Nine Mile Creek of the Guyandotte; from a bed 4-feet thick, taken from the Aspinwall and Low lands on Four Mile Creek, of same river; and from the McComas Bank, on the Guyandotte River, five miles above the falls, where the bed is 8-feet thick. The appearance of these coals was fair, but, until better means of transportation exist, it will be impossible to develope the coal-seams of this county to any great extent.

Returning to the Great Kanawha River, if we continue to descend this stream, Putnam County is the next point reached. Here the Pittsburgh bed is worked by the Raymond Coal Company, at a point where the seam averages 6 feet 2 inches in thickness. The coal mined here is of excellent quality, and is sent westward for domestic and steam use; but in spite of the high percentage of volatile combustible matter the coal contains at this point, it is not sold for gas manufacture, as other coals close at hand are so much superior for this purpose. An analysis of the coal gives:

Volatile combustible matter	33·00
Fixed carbon	60·00
Ash	6·00
	99·00

A specimen of the same bed, in the same county, was shown from the lands of J. L. McLean on Guano Creek, where the seam is 6⅓ feet thick. A specimen of bituminous coal from Mason County, adjacent to Putnam, was exhibited from the mine of the Hartford City Coal and Salt Company. The mine is located on the Pittsburgh seam, which is here 5 to 6 feet thick, and crops out on the Ohio River. The coal is worked for consumption at the salt works and for exportation down the river. It is inferior in quality to that mined in Putnam County, and sells for a lower price. The analysis of this coal, as given by the State Commissioners, gives:

Moisture	3·43
Volatile combustible matter	44·38
Fixed carbon	46·88
Ash	5·31
	100·00
Sulphur	1·57

Wayne County is in the extreme western corner of the State, and it was represented by specimens of coal from the lands of Aspinwall and Low, Wayne Ferguson, and Walter Osborn. They were all from different branches of Twelve-Pole River. The coal from the lands of Aspinwall & Low is a cannel, which probably comes from a bed 8 feet thick, in which there are 7¼ feet clear coal, of which 5½ feet are cannel. There were specimens of cannel and bituminous coal from the lands of Wayne Ferguson, the former said to be from a bed 7½ feet thick, and the latter from one 4⅓ feet, while Walter Osborn exhibited a specimen of coal from a bed 5½ feet thick. It has been impossible to ascertain how far these coals are being worked, or whether the analyses given below are taken from outcrops or from workings.

I. Coal from W. Osborn's land. II. Coal from the land of W. Ferguson.

	I.	II.
Moisture	2·30	1·56
Volatile combustible matter	40·43	43·22
Fixed carbon	48·72	44·89
Ash	8·55	10·33
	100·00	100·00
Sulphur	0·76	0·82

Kentucky.

Directly west of West Virginia lies the State of Kentucky, which was finely represented by the coals displayed in the collection of the State Geological Survey, and although the size of the specimens in many cases was small, still, the different localities represented were very numerous. This State contains at its eastern end a continuation of the Alleghany coal-field, while the western portion also contains the southern prolongation of the Illinois coal-field. Confining our attention for the present to the former, it may be stated that Kentucky, like West Virginia, rejoices in a great variety of coals, as yet but little developed, which belong to the series below the Pittsburgh bed, and occur either in the coal measures proper or the underlying conglomerate. It was impossible to judge of the quality of the coal-beds from the small specimens exhibited, and never having had the opportunity of examining the coal-field in person, it has been impossible for the writer of this report to give as clear an explanation of the nature of the coals as would otherwise be the case; and as a large portion of the district has not yet been examined by the officers of the State Geological Survey, it has been impossible to obtain a full description of the nature and quality of the coal-beds.

The cannel coals of Eastern Kentucky represented a greater area and thicker cannel beds than any other exhibit; as coals of this character representing workable beds were exhibited from the Ohio river at Greenup County, and near Cumberland Gap.

The area of the eastern coal-field is 8,983 square miles. Twelve coal-beds are known to exist above the great conglomerate, while in the south-eastern counties two, and possibly three, beds occur in the conglomerate, which are some of them thick enough to mine. These latter coals occur all along the western margin of the coal-field, being in places 4 to 5 feet in thickness, but their remoteness from market, and the presence of coals much superior in quality and in thicker seams, will probably confine their exploitation and development to the requirements of the neighbouring population.

The first bed above the conglomerate is the equivalent of the Ohio Brier Hill coal. It varies in thickness, being at times too thin to be profitably mined, but, where developed, it has apparently a local uniformity, which will permit of its being easily extracted where sufficiently thick. Its thickness gradually increases from the Ohio River, where it is 15 inches, to Warfield, in Martin County, where it is 5 feet. Towards its western outcrop it generally thins out along the line of its outcrop, where it occurs in the tops of the hills. This coal varies in quality at different points, but is generally a splint or open-burning coal in character. It has not as yet been tried in the blast-furnace, but from some of the analyses given below, it is in places too high in sulphur to be well adapted for iron-smelting. The Geological Survey of the State furnished me with the following analyses:—

I. Little Fork, near Willard, Lawrence County.

II. Sweetman's, near the Ohio River.

	I.	II.
Moisture	3·50	5·10
Volatile combustible matter	36·30	35·30
Fixed carbon	57·30	57·80
Ash	2·90	1·80
	100·00	100·00
Sulphur	1·15	0·73

Near the Ohio this coal is said to be less reliable in quality than in Carter and Lawrence Counties.

The second bed is of less importance than the preceding: it covers a wide extent of country, however, and is in places of good quality and thick enough to mine. It varies from 2 to 3½ feet in thickness, and it is at present mined for local use. The State Survey furnished me also with an analysis of this bed from Kibby's opening, on Everman's Branch, Carter County.

Moisture	4·10
Volatile combustible matter	34·60
Fixed carbon	55·25
Ash	4·77
	100·00
Sulphur	1·41

The third coal above the conglomerate is probably the Kittanning coal of Pennsylvania; it varies from 2½ to 6 feet in thickness; the latter being at Peach Orchard, on the Big Sandy River. The character of the coal is usually bituminous, although it sometimes contains a layer of cannel. The following analyses, furnished by the State Survey, serve to illustrate the quality of the coal:—

I. Average of five analyses from Greenup County.
II. Average of four analyses from Lawrence County.
III. Carter Farm, Carter County.

	I.	II.	III.
Moisture	3·56	3·11	3·00
Volatile combustible matter	35·00	36·23	36·20
Fixed carbon	52·34	54·33	49·24
Ash	9·02	6·30	11·56
	99·92	99·97	100·00
Sulphur	2·59	2·87	1·38

The next, or fourth coal, is less persistent than No. 3; in character it is a cannel, with portions of the bed bituminous. The cannel portion of this bed is sold in the market under the name of Hunnewell cannel. The thickness of the bed varies from 2½ to 5 feet; but in places, as, for example, in Lawrence County, it seems to be entirely wanting. An analysis in the report of the old Geological Survey of this coal, taken from Stinson Bank, Carter County, gives—

Moisture	0·60
Volatile combustible matter	66·30
Fixed carbon	28·30
Ash	4·80
	100·00
Sulphur	1·32

The amount of volatile matter in this coal is remarkable.

The fifth coal-bed in the series is known locally as the Pennington and Cooksie Fork coal, its greatest development being in Lawrence and Carter Counties. The quality of the coal has not been fully ascertained, as it is only mined at the Buena Vista furnace. Here the thickness of the bed is 38 to 40 inches, and the coal is said to be of a good quality. Its composition, as given by the officials of the State Survey, is—

Moisture	3·20
Volatile combustible matter	32·30
Fixed carbon	53·00
Ash	11·50
	100·00
Sulphur	1·20

The large percentage of ash is probably due to the upper slaty layers included in the sample which was taken, and which can be rejected in mining.

The sixth coal-bed has its greatest developement in Boyd County; it is known locally as the Keys Creek or River Hill coal. In Greenup County it also occurs, but is less reliable, both as to quality and thickness. It is mined at Louise, in Boyd County (the north-easternmost county of the State); it is

a little over 2 feet thick, and is of a good quality. An average of four analyses, made by the chemist of the Geological Survey, gave—

Moisture	3·27
Volatile combustible matter	33·77
Fixed carbon	54·51
Ash	8·91
	100·46
Sulphur	1·56

The seventh coal-bed is widely known as the Coalton coal. It is extensively worked at Willard, on the Eastern Kentucky Railroad, and at Coalton and a number of points on the eastern division of the Lexington and Big Sandy Railroad. The coal is splint in character, and is widely used in a raw state in blast-furnaces, for which purpose it enjoys a high reputation. It usually occurs in a bed 3½ to 6 feet thick in two or three parts, with partings between, each part being about 2 feet thick. Where the seam is less than 6 feet the upper part is missing. The following is an average of twelve analyses of this coal, made by the State Survey:—

Moisture	5·19
Volatile combustible matter	32·04
Fixed carbon	55·59
Ash	6·71
	99·53
Sulphur	1·68

Coal No. 8 is also mined at Coalton, where it is reported to be in a bed of 4 feet of clear coal. In quality it is inferior to the last-named.

The following table, sent me by Mr. A. R. Crandall, assistant on the State Geological Survey of Kentucky, will show at a glance the area and thickness of the different coal-beds.

GREENUP COUNTY.*

	Number of Coal-bed.						
	I.	II.	III.	IV.	V.	VI.	VII.
Greatest thickness	36	30	60	50	?	54	36
Ordinary „	24	20	36	30	?	30	36
Area in square miles	340	300	215	175	110	60	30
„ below drainage	65	47	—	—	—	—	—

CARTER COUNTY.*

	Number of Coal-bed.								
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Greatest thickness	50	37	40	?	72	24	60	55	24
Ordinary „	30	20	30	?	?	20	36	36	20
Area in square miles	360	315	276	270	140	132	76	68	60
„ below drainage	98	85	62	57	49	40	30	13	9

* The thickness of the coals is given in inches.

Boyd County.*

	Number of Coal-bed.								
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Greatest thickness	—	—	35	30	40	46	72	48	25
Ordinary „	—	—	30	?	28	38	52	30	20
Area in square miles	169	169	169	169	169	169	160	158	155
„ below drainage	169	169	160	157	135	100	60	32	25

Lawrence County.*

	Number of Coal-bed.										
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.
Greatest thickness	36	20	73	—	84	46	36	40	—	30	43
Ordinary „	30	20	36	—	36	24	30	36	?	?	?
Area in square miles	386	386	386	—	386	356	320	285	250	175	140
„ below drainage	210	180	164	—	80	50	42	25	10	—	—

Tennessee.

The only coals exhibited from this State were from Anderson County and the neighbourhood of Chattanooga. The coals from the former locality were exhibited by the Poplar Creek Mineral Railroad Company from the line of their road. The bed chiefly worked is said to be 7 feet thick; it is a hard, free-burning splint coal, which is nearly free from sulphur, and when once ignited burns like a candle. It is used in blast-furnaces, and is very well adapted for this purpose. The coals from the Chattanooga district not having been seen, it is impossible to describe them.

Alabama.

The Selma & Alabama, and South & North Alabama Railroads exhibited columns showing a complete section of the rocks crossed by the lines of their roads, which were extremely instructive. The South and North Alabama, and the Selma, Rome, & Dalton Railroads displayed coal from along the line of their roads.

The three coal-fields of Alabama, called the Warrior, Cahaba, and Coosa, embrace an area exceeding 7,000 square miles,—the two latter being separated from the former by a series of anticlinal Silurian valleys. From recent data obtained by the South and North Alabama Railroad, it was found that the Warrior coal-field contains forty-six seams of coal, from 1 inch to $6\frac{1}{2}$ feet in thickness, of which sixteen measuring over 2 feet in thickness are considered workable. The Cahaba coal-field embraces fifteen beds of coal from 1 inch to $6\frac{1}{2}$ feet in thickness, of which sixteen are considered workable, as being over 2 feet in thickness. In the former field four, and in the latter seven, seams are now being worked. Some of the coals make an excellent coke suitable for blast-furnace use, while others are open, burning splint coals. At present the Eureka Company is coking 70 tons a day in Belgian ovens, principally from the Wadsworth bed, and the coke made produces a good quality of foundry pig from fossil ore. Some of the beds also yield coals which generate steam most capitally. From the data it was

* The thickness of the coals is given in inches.

possible to obtain it was impossible to ascertain what the quality of the different coals exhibited was; consequently those exhibited are merely mentioned, and the analyses given that were attainable. As yet the coal-fields of Alabama have never been developed to any extent, and it will require this impulse to ascertain what the real nature of many of the coals is.

CAHABA COALS.—Helena bed, mined by Byram & Bowers, and Mrs. Alois; coal 3 to 5 feet thick. An analysis by Otto Wuth shows:—

Moisture	0·23
Volatile combustible matter	35·53
Fixed carbon	61·26
Ash	5·85
Sulphur	0·13
	100·00

Beaver Dam bed, worked by Robert Peal & Co.; thickness of bed 3 to 4 feet. Analyzed by Otto Wuth:—

Moisture	0·30
Volatile combustible matter	31·36
Fixed carbon	65·45
Ash	2·81
Sulphur	0·08
	100·00

Black shale bed, mined by the Eureka Company; coal 4 feet thick. Analyzed by Otto Wuth:—

Moisture	0·21
Volatile combustible matter	33·28
Fixed carbon	64·10
Ash	2·34
Sulphur	0·08
	100·01

Buck bed, mined by Eureka Company; coal 3 to 4 feet thick. Analyzed by Otto Wuth:—

Moisture	0·17
Volatile combustible matter	25·97
Fixed carbon	70·10
Ash	3·68
Sulphur	0·07
	99·99

Wadsworth seam, worked by Eureka Company; coal 3 to 4 feet thick. Analyzed by William Gesner:—

Moisture	0·38
Volatile combustible matter	31·78
Fixed carbon	64·36
Ash	2·96
Sulphur	0·53
	100·01

Cahaba bed, worked by Davis & Carr and S. D. Holt; coal 4 to 5 feet thick. Analysis by R. P. Rothwell:—

Moisture	1·58
Volatile combustible matter	32·60
Fixed carbon	62·62
Ash	3·20
	100·00
Sulphur as sulphate	0·23
Sulphur as sulphuret of iron	0·73

The Montevallo bed is worked by Dr. T. H. Aldrich. Analysed by R. P. Rothwell :—

Moisture	2·13
Volatile combustible matter	27·03
Fixed carbon	66·22
Ash	4·62
	100·00
Sulphur as sulphate	0·11
Sulphur as sulphuret of iron	0·39

Warrior Coals.—The New Castle bed is worked by the New Castle Coal and Iron Company. The seam is 5 feet 8 inches thick, with a shale parting of 5 inches.

The Morris bed is mined by the Jefferson Mining Company, the coal being 3 feet thick, with a shale parting of 4 inches.

The Black Creek bed is mined by the Jefferson and New Castle Companies, the coal being 3 to 4 feet thick. The latter company have opened the bed at a point 22 feet above the level of the railroad, at a place where it is very convenient to ship it. This coal has been sent to the Nashville gas-works, where it was much liked on account of the small per-centage of sulphur and clinker and the excellent quality of the coke made from it. The amount of combustible volatile matter it contains is very great according to the statements made, being 10,976 cubic feet of gas of 14½ candle-power per gross ton, and cannot be brought into accordance with the analysis given below.

The Pierce bed is mined by the Pierce, Warrior, and Alabama Mining Companies, the coal being 3 to 4 feet thick. One peculiarity of the Warrior coal-beds is the presence of partings, in which fact they differ from the Cahaba coals.

The following are the analyses of these coals, so far as they could be obtained ;—

I. New Castle bed, analyzed by Otto Wuth. II. Morris bed analyzed by William Gesner.

	I.	II.
Moisture	0·50	0·12
Volatile combustible matter	28·24	26·11
Fixed carbon	59·69	71·64
Ash	10·92	2·03
Sulphur	0·64	0·10
	99·99	100·00

The next coal-field is the so-called Eastern Interior Coal-Field, which includes the coal found in the States of Indiana, Illinois, and Western Kentucky.

Indiana.

There were two distinct displays of coal from Indiana, one being at the State Building, the other in the Mineral Annex to the Main Building. The former was very fine, consisting of large blocks weighing one to three tons each, and comprised the three varieties found in the State; viz., caking, block or splint, and cannel. Many of the blocks exhibited the entire thickness of the beds from which they were taken, and were designed to convey a proper idea of the character and quality of the coal-beds. The entire display was due to the energy of Professor E. T. Cox, State geologist of Indiana. The specimens in the Mineral Annex were small.

There are three workable beds of caking coal in the State, ranging from 4½ to 10 feet in thickness, and three seams of block or splint coal that range from 2½ to 5 feet, the average thickness being 4 feet. Thus far only one bed of cannel coal has been developed, and is extensively mined in Daviess County.

Parke County is the most northern portion of the State from which specimens were exhibited, and they came from the Sand Creek Coal Company's mines. There are two seams of coal on the property, of which the upper one, which is an excellent caking coal, 4½ feet thick, is chiefly mined. An analysis of this coal by the State Geological Survey gave :—

Moisture	4·50
Volatile combustible matter	45·50
Fixed carbon	45·50
Ash	4·50
	100·00

The coal enjoys a high reputation for locomotive and general uses.

The display from Clay County was quite extensive, consisting of block or splint coal from the mines of Niblock, Zimmerman, & Alexander, Black Diamond Mine, Clay Coal Company, Jackson Coal Mining Company, B. F. Masten, Otter Creek Coal Company, Yandes, Root, & Garbick, and Woodruff & Fletcher, all at Brazil; of the Watson Coal Mining Company, at Knightsville; and of the Carbon Coal Company, at Carbon; of caking coal from the Locust Grove Mine, at Warwick; of the Ingleside Mining Company, at Vanderburg; and of the Cincinnati & Mutual Company, at Cloverland. The block coal is mined by all the companies from three seams. The coal bears a high reputation for iron-smelting and steam purposes, is remarkably free from sulphur, and contains but a small amount of ash. As samples of these coals, two analyses made by the Geological Survey are given :—

	I. Garlick & Collins' mine.	II. Barnett's mine.
	I.	II.
Moisture	8·50	4·00
Volatile combustible matter	31·00	37·50
Fixed carbon	57·50	57·00
Ash	3·00	1·50
	100·00	100·00

The caking coal from Clay County comes from one bed which is 6 to 8 feet thick, having one or two clay partings. The upper 6 inches of the bed are frequently quite sulphurous. The coal will not answer for iron-smelting unless it is coked; but it is said to be excellent for domestic and steam purposes. A characteristic specimen of the coal analyzed by the State Survey gave :—

Moisture	7·00
Volatile combustible matter	39·70
Fixed carbon	47·30
Ash	6·00
	100·00

From Vigo County, the Litchfield Coal Company exhibited a specimen of caking coal, and a specimen of the same sort of coal was exhibited from Owen County, taken from Amey's mine.

From Sullivan County, there were specimens from the workings of Banholzer & Son and H. K. Wilson. The coal from both is of the caking variety; it belongs to the "M" coal-bed of the Indiana Geological Survey, and varies from 4 to 9 feet in thickness, with two or three partings in the seam. An analysis of the coal from the Wilson Mine, made by the Survey, shows :—

Moisture	2·35
Volatile combustible matter	45·25
Fixed carbon	51·60
Ash	0·80
	100·00

The yield of gas is large, but as there is no sulphur given with the analysis, it is impossible to say how well adapted it may be for this purpose.

From Martin County, there was a specimen of the coal worked at the Baker Mine, at Shoals. Here a sub-conglomerate seam, 3 to 4 feet thick, is mined; it is a good block or semi-block, and is well adapted for use in the blast-furnace. Analysis of this coal by the Survey gave:—

Moisture	2·50
Volatile combustible matter	44·75
Fixed carbon	51·25
Ash	1·50
	100·00

From Daviess County, there were exhibited specimens of cannel coal from the Buckeye Cannel Coal Company, at Cannelsburg; of block, from Colonel J. S. Morgan's mine, at Black Oak Station, and E. H. Raymond's, at Washington; and of caking coal, from Cabel, Wilson, & Co. and Spink & Cabel, at Washington. The caking coal was taken from the "L" coal-seam of the Indiana Survey; it is an excellent caking coal, 3½ to 5½ feet thick, and is quite free from sulphur. An analysis of the coal from Spink & Cabel's mine, by the Geological Survey, gave:—

Moisture	5·50
Volatile combustible matter	30·00
Fixed carbon	60·00
Ash	4·50
	100·00

The block coal belongs to the "X" coal-bed of the State Survey; it is 2 to 5 feet thick, and, as seen from the analysis of Raymond's coal below, sometimes contains more gas and less ash, water, and fixed carbon than "L." The samples analyzed by the Geological Survey gave:—

	I. Raymond's mine.	II. Colonel Morgan's mine.
	I.	II.
Moisture	1·00	5·50
Volatile combustible matter	46·50	36·00
Fixed carbon	50·75	53·50
Ash	1·75	5·00
	100·00	100·00

This is the only county in which cannel coal has thus far been discovered; it is 4½ feet thick, and is as solid as a rock, being so firm and durable that it has been used in the foundations of the engines and tip-houses at the mines. It burns without snapping or throwing out flakes, and yields, on distillation, the enormous quantity of 11,648 cubic feet of gas of 25 candle-power per gross ton, according to the State geologist. It is, consequently, widely used as an enricher by the gas companies, and is also held in high esteem as a grate-fuel. The cannel coal in this bed is firmly attached by the bottom to 18 inches of jet-black caking coal. It is very free from pyrites, and contains 7 to 10·5 per cent. of ash, which is very white.

The exhibit from Knox County comprised the caking coal mined at Edwardsport by T. H. Shepard, Thomas Curry, and Muer and Freeman, and of block coal from Helphenstein's mine at Bicknell. The coal-bed mined at Edwardsport is the "L" of the Indiana geologists. It is a free semi-caking coal, is 5 feet thick, and is usually free from sulphur. It is well adapted for locomotive, rolling-mill, or engine use. An analysis of the coal from Curry's mine, by the State Survey, gives:—

Moisture	4·00
Volatile combustible matter	34·50
Fixed carbon	57·00
Ash	4·50
	100·00

Helphenstein & Co. also exhibited a specimen of coal from the town of Bicknell.

The coals of Spencer County were also represented. The seam mined is the "L" bed of the Indiana Survey, locally called the "knob coal." Specimens were sent by J. S. Alexander, the Steats Bank, and Bar and Brother. An analysis by the Geological Survey of coal from the latter bank showed—

Moisture	3·50
Volatile combustible matter	45·00
Fixed carbon	46·00
Ash	2·50
	100·00

The coal is of a splint or open-burning kind, and is used for the same purposes as that taken from the same bed elsewhere.

Western Kentucky.

The coal-field of Western Kentucky is a continuation of the Indiana and Illinois coal-field. It was extensively represented at the Centennial Exhibition. Unfortunately, however, the identification of the different beds of this district is still in a very backward condition, the present geological survey of the State having but recently taken up the subject; in addition, many of the specimens were taken from banks but little opened, where the nature of the coal is as yet undetermined. It was, of course, impossible for the writer of this report to determine the nature of the coals by a mere inspection of small specimens; it has therefore seemed best to him to give a brief outline of the different beds of the State, not mentioning the different coal-banks from which the specimens were exhibited.

The number of coal-beds in the western coal-field, taking into account all of the beds which are to be found in the space between the conglomerate at the base of the measures and the "Anvil Rock" sandstone is twelve. This number is not constant, however, but varies according to localities. Letters are used to designate the beds, and the lettering begins with the first coal below the "Anvil Rock." Beginning with the uppermost bed in the series included between the Anvil Rock sandstone and the conglomerate, the several coals may be briefly described as follows:

Coal A.—This is the bed more commonly known as "No. 12." Although present over a considerable extent of territory, it is mined very seldom, as its position near the summit of the formation usually brings it near the tops of of the hills, and it is thus seldom found in a suitable condition for working,—the covering being insufficient and the coal too soft, or too untrustworthy in its linear extent; it frequently happens that the coal is only indicated by a mere stain or a smutty dirt. When found in a workable condition, however, this coal is comparatively free from all irregularities in its bedding, and is easily mined. When well developed it varies in thickness from 3 to 6 feet. In texture it is somewhat variable, occurring as a firm, glossy black, dense coal at one locality, while at another it may be soft and rather fragile,—apt to disintegrate upon long exposure. Unfortunately, it has not been found possible to obtain as large a number of trustworthy samples of the coal for analysis as would be desirable, but the results obtained from those samples which have been examined prove the coal, when compared with other beds, to contain but little sulphur,—little more, in fact, than is contained in the celebrated block coal of Indiana. The following is a generalization of the analyses which have been made up to this date:—

Moisture	4·15
Volatile combustible matter	33·14
Fixed carbon	55·71
Ash	7·00
	100·00
Sulphur	1·87

The percentage of sulphur in certain samples of the Indiana block coal has been determined to range from 1·664 to 1·802. The fact of its being too fat precludes the possibility of making good iron with the coal in a raw state. It was thus used at the Airdrie furnace, on the Green River, but the quality of iron produced was poor. Excellent coke may be made of it, however, and when thus used there is no good reason why a fair quality of iron may not be obtained. An analysis of the coke prepared from it some seventeen years ago for use at the Airdrie furnace, and left exposed to the action of the weather ever since, shows its composition to be as follows :—

Moisture expelled at 212°	7·50
„ „ at red heat	4·20
Fixed carbon	82·90
Ash	5·40
	100·00
Sulphur	0·64

As will readily be understood, the above does not fairly represent the quality of coke that can be made of the coal, as a large percentage of the moisture indicated is undoubtedly due to absorption; it is equally true that the coke may have parted with some of its sulphur. It should be known, also, that the coke was prepared in open heaps instead of such improved ovens as are now in use.

Coal B.—This bed is, taking the field through, quite untrustworthy. It thins and thickens in a remarkable manner, and it is seldom free from "slips" and such irregularities. It is much more persistent than Coal A however. It is always found with one clay parting, rarely two. When workable the coal is of fair quality, as a fuel for general purposes, although rather too soft to withstand a long period of "yarding." As a bed it possesses some remarkable properties. It is glossy black and compact in its larger part, although frequently having fibrous coal between the laminæ. The upper part of the bed is, on an average, the best, the quality deteriorating towards the bottom. The following is an average of six analyses made of fairly-averaged samples of the coal :—

Moisture	3·65
Volatile combustible matter	38·40
Fixed carbon	51·87
Ash	6·06
Sulphur	3·12

This analysis represents the general character of the full bed, and is a general average of the quality of the coal as found over a wide area extending from the eastern border of Muhlenburg County to the central portions of Hopkins County.

The two following are averages of (I.) four analyses of the upper member of the coal, which measures from 3 to 4 feet, and (II.) of three analyses of the lower member, which measures from 2 to 2½ feet in thickness :—

	I.	II.
Moisture	3·46	3·67
Volatile combustible matter	38·17	37·42
Fixed carbon	50·42	50·73
Ash	7·93	9·16
Sulphur	2·49	4·69

It will be seen that the larger portion of the impurities occurs in the lower member of the coal. The superiority of the upper member does not rest here alone, however. It is not only of a better quality as a whole, but has a distinct layer at the top, from 16 to 20 inches thick, which is remarkably rich in gas, and contains but little sulphur.

The following is an average of two analyses of the gas coal :—

Moisture	4·60
Volatile combustible matter	40·10
Fixed carbon	51·35
Ash	3·95
	100·00
Sulphur	1·491

It is very practicable to separate this gas coal from the other parts when mining, and if this is done the inland towns can be furnished with cheap Kentucky coal instead of the more expensive article now generally used for the manufacture of their gas.

Coal B is wrought at many points in the coal-field, and often lies above drainage. It is found towards the Ohio River, in Henderton and Daviess Counties; in the western parts of Union and Webster Counties; widely distributed over Hopkins and Muhlenburg Counties; at many points in the southern half of Ohio County, and is known to occur towards the Green River in McLean County.

Coal C.—This bed is very erratic and is rarely present. It usually occurs merely as a smut of 2 inches in thickness; but has been reported to measure as much as 2½ feet. It has been observed in but a few localities, and is so variable that it has no value.

Coal D.—This bed is the one known as "No. 9" in the reports of the first geological survey. The coal varies in its general quality and physical features, but has a remarkable uniformity in the amount of sulphur it contains. It is usually hard and compact, made up of alternating dull and glossy black laminæ, with layers of fibrous coal between, which gives it an appearance remotely resembling splint coal. It is an admirable heating fuel, and as such, when properly screened, is of peculiar value. It is highly esteemed for that purpose, but is too fat and sulphurous for use in the blast-furnace. The upper 2½ feet are usually the best, being generally freer from pyrites than the lower portion. It is believed that the larger portion of the sulphur in the coal is contained in the iron pyrites, which are always found in it. Fortunately, the larger portion of the pyrites occurs as bands, and may be removed when the coal is mined. The coal is remarkably persistent and uniform in thickness, and is found above drainage, or less than 75 feet below it, over a larger extent of territory than any other bed in the Western coal-field. From this fact it may be considered as having a greater general value, for the present at least, than any of the other coal-beds in the south-western portion of the State. Its thickness ranges from 4 to 6 feet, averaging about 4 feet 8 inches. The following is an average of twelve analyses of the coal:—

Moisture	3·82
Volatile combustible matter	35·41
Fixed carbon	52·11
Ash	8·41
Sulphur	3·33

This coal is always provided with a trustworthy roof, and may be mined with safety and comparative ease. It is worked at many points along the Louisville, Paducah, and South-western Railroad, at several points along the St. Louis and South-western Railroad; along the Evansville, Owensboro', and Nashville Railroad, in the south-western portion of Union County; towards the Tradewater River in Webster County; very generally over Hopkins and Muhlenburg Counties, and is frequently exposed and worked in the northern portion of Daviess County, towards the Ohio River, and in the south-western quarter of Ohio County.

Coal E.—This bed, when well developed, has the appearance of being very fair in quality, being a glossy black, firm, even-textured coal. It is one of the most remarkable coals in its variations in thickness, however, to be found in the field. It is sometimes entirely absent, and when present it varies from ½-an-inch to 2½ feet in thickness. It is believed to be of such superior quality when fully developed that a thickness of 3 or 3½ feet would be regarded as workable even in the region of thicker beds. Unfortunately, no analyses have yet been made of it by which its true worth may be determined.

Coal F.—So far this coal has not been found valuable, either in an economic or a commercial point of view. It is proper to state, however, that but little is known of it, as, until very recently, its horizon was seldom found. It is not improbable, therefore, that the coal may prove valuable in some parts of the field.

Coal G.—As yet little is known concerning this coal. So far as known at present, the bed is thin and of little value.

Coal H.—This bed has been seldom found. It varies, so far as known, from less than 4 feet to 5 feet in thickness, and is usually divided at from

2½ to 3½ feet from the bottom by a clay band from 2 to 5 inches in thickness. No analyses have yet been made of this coal; but it seems safe to state that, judging from its appearance in the bank and from general report, it is in part of very fair quality. The upper member is, so far as proved, very soft and fragile, and concretions of iron pyrites occur in the bed; but the larger part of the lower member is very firm, and seems to be of excellent quality.

Coal I.—There is little definitely known concerning this coal; a full description of it cannot, therefore, be given. It has been observed at a few points, measuring from 1 to 3 feet in thickness, and apparently of good quality. It is above drainage in the south-western quarter of Hopkins County, in Union County, the southern part of Ohio County, and probably in the southern part of Muhlenburg County.

Coal J.—This coal varies from 2 to 3½ feet in thickness. It has been mined at but few places. There is considerable fibrous coal between the laminæ, on account of which the coal withstands exposure poorly; the percentage of sulphur is also high. The following is an analysis of the bed as it occurs at Petersburg, Christian County:—

Moisture	3·70
Volatile combustible matter	32·56
Fixed carbon	50·04
Ash	13·70
	100·00
Sulphur	3·72

This bed is found in the region eastwardly from Caseyville, in Union County; in the region around Petersburg and southwardly from there, in Christian County; and frequently along the disturbance which extends through Union, McLean, Webster, Ohio, and Grayson Counties.

Coal K.—This bed seems to be quite limited in its distribution. It is not probable that it will anywhere be found having much value. This, however, is a mere surmise, as very little is known concerning the coal.

Coal L.—This is, perhaps, the poorest coal, having great extent in the field. It is found above drainage, or but little below it, around the eastern, southern, and western margins of the field; the low bed worked at Hawesville and vicinity, in Hancock County, near the Ohio River, may also correspond to this number. The bed is also lifted above drainage from Union County, across Webster (passing near Sebree Springs), McLean, and Ohio Counties, into Grayson County. The coal has been, or is now, wrought at the Coaltown banks, in Christian County; in the vicinity of Tradewater Station, in Hopkins and Caldwell Counties; in the region around Caseyville, in Union and Crittenden Counties; near Wrightsburg (?), in McLean County; and has been opened at a number of points in Edmondson, Grayson, and other counties. It varies from 3 to 5½ feet in thickness. The following is an average of four analyses of the coal:—

Moisture	4·23
Volatile combustible matter	33·21
Fixed carbon	54·19
Ash	8·35
Sulphur	1·50

The Breckenridge cannel coal is the first coal above the sub-carboniferous series. It is celebrated for its remarkable properties as an oil producer and gas enricher. A fine specimen of it was placed on exhibition shortly before the close of the Centennial. The coal is so rich in volatile bituminous matter that oil was distilled from it prior to the discovery of petroleum, and it was at one time sent all the way to New York as an enricher in the gas-works. The coal, so far as traced, seems to be confined to Breckenridge and Hancock Counties. The thickness of the seam is 22 to 38 inches. The coal is remarkably dense and tenacious, and resists cross-fracture. More oil can be obtained from it than from the famous Scotch Bog-head cannel, which yields 72 gallons of oil and 12 pounds of paraffin, while the Breckenridge cannel yields 92 gallons of marketable oils. At present, however, its greatest value is as a gas producer

or enricher. Three analyses are appended of this coal: I., by Dr. Peter; II., average of four analyses made by D. D. Owen, both of the Kentucky Survey; III., by Gesner:

	I.	II.	III.
Moisture	1·30	1·44	6·45
Volatile combustible matter	54·40	62·40	61·30
Fixed carbon	32·00	28·20	30·00
Ash	12·30	7·96	8·05
	100·00	100·00	105·80

Dr. Peters states that in one specimen of air-dried coal he found the percentage of sulphur to be 2·443. It only needs a good means of transportation to have this coal transported large distances for gas purposes.

Illinois.

The only coal from the State of Illinois was exhibited by the Grand Tower Mining, Manufacturing, & Transportation Company, and is known all over the West as "Big Muddy Coal." The bed mined is 5 feet thick, with a slate parting of 2 inches at about the middle. Although of an inferior quality compared to the Indiana and more Eastern coals, it is the best as yet found in the State. It is a block or splint coal, and is used for iron-smelting, and when properly prepared will give a tolerable grade of pig-iron; it is also used for steam and domestic purposes. An analysis of the coal by the Illinois Geological Survey gave:—

Moisture	6·50
Volatile combustible matter	31·20
Fixed carbon	60·80
Ash	1·50
	100·00

The amount of sulphur is not stated.

Iowa.

The coal in Iowa, together with that found in Missouri, Kansas, and Arkansas, belongs to the Western Interior Coal-field.

There were but two exhibits of coal from this State; one from the mines of Wesley Redhead, at Des Moines, the other from the Mahaska Coal Mining Company, in Mahaska County. The coal at the former mine is 4½ to 6 feet thick, and at the latter locality 7 to 9½ feet. All the Iowa coal is of inferior quality, and only adapted to domestic and steam use. Indeed, it is not much liked for the latter purpose on locomotives, as, owing to the high percentage of pyrite and ash in the coal, it readily forms large quantities of clinker, and on this account wood, or more Eastern coals, are often used in preference.

Missouri.

The Hannibal & St. Joseph Railroad Company exhibited coal from along the line of their road in Macon, Linn, Howard, and Livingston Counties. As yet, however, the correlation of the different beds has not been established by the State Geological Survey, nor was it possible to say much from the samples exhibited. It is a well known fact that the Missouri coals are all, so far as they have been hitherto examined, of an inferior quality. They contain from 2 to 6, or even more, per cent. of sulphur, and 2 to 10 per cent. of moisture, while they are all high in ash. Some of the coals coke, others will not. They are totally unfit for iron-smelting, as is well attested by the fact that the blast furnaces around St. Louis all use Youghiogheny coke or Big

Muddy coal. They are, of course, of an inferior quality for steam-raising, gas-making, and domestic purposes. The analysis of the coal from the Bevier Mine, in Macon County, made by the chemist of the State Geological Survey, will serve as a sample. It will be observed that the percentage of sulphur is not given.

Moisture	12·05
Volatile combustible matter	40·75
Fixed carbon	43·50
Ash	3·70
	100·00

Great Britain.

The exhibits were by the West Cumberland Iron & Steel Company, the Wigan Coal & Iron Company, Frederick Dixon, and Elizabeth Marriott.

The West Cumberland Iron & Steel Company exhibited coal and coke used at their works; so far as could be judged from the specimens exhibited, both were of an excellent quality; no information was given with the exhibits as to the basin or bed from which the coal came.

The Wigan Coal & Iron Company exhibited specimens of their gas and cannel coals, too widely known to need any description.

Frederick Dixon and Elizabeth Marriott exhibited specimens of patent fuel, but, so far as could be ascertained, neither of them has as yet attained any importance.

Portugal.

This country sent a few small specimens of coal, which, according to the Catalogue, were exhibited by B. Rodrigues d'Oliveira from San Pedro de Cova, by the Industrial Union Company from Povoa de Pedoride, and by Frederico de Cabral from Monte das Cavadinhos. The specimens themselves were too insignificant to enable one to judge as to their quality, nor were any analyses or information furnished as to their value economically.

Spain.

The exhibits of coal from this country were numerous, but for the most part very small in size, so that it was impossible to form any idea as to their quality. The information furnished was of the scantiest nature, nor were any analyses given with the exhibits from which any opinion as to the real value of the coals as fuel could be formed. This is the more to be regretted, as many of the specimens looked well, and probably would compare favourably with many British and American coals. The following is a list of the exhibits: from the Province of Barcelona, by La Perla Bergadana Mining Company and Gispert y Pujals; from the Province of Burgos, by Eugenio Oria and the Juaneña Society; from the Province of Castellon, by Miró y Cerda; from the Province of Cardoba, by the Coal-Pit Company of Belmez; from the Province of Gerona, by El Veterano Mineral Society; from the Province of Oviedo, by the Board of Agriculture, Industry, and Commerce, the Coal-Pit Society of Muñon, the National Works of Trubia (which also exhibited coke from the coal), Garcia de los Rios and Braulio Vignon (anthracite); from the Province of Palencia, by the mines of Castilla (together with the coke made from the coal); from the Province of Seville, by Isaac Pereire; and from the Province of Teruel, by Andres Peguero and Francisco Sierra.

Sweden.

The only coal-field of Sweden which has been developed, or is of any importance, is an extremely limited one, occurring in the Province of Skane, the most southern portion of the country. The coal does not belong to the true

Carboniferous formation, being of a more recent age, and occurs in rocks of Triassic or Jurassic age.

The only exhibit made was by the Höganäs Coal Mining Company, where mining was commenced in 1797. The bed now worked lies at a depth of 60 to 280 feet, and is 4·8 feet thick. Of this, however, but 7 inches is of first quality, 14 inches of second, and 5 inches of third quality, while the rest consists of a dark carbonaceous slate. Analyses of the coal made by E. Erdman of the Geological Survey gave :

	1st quality.	2nd quality.	3rd quality.
Volatile combustible matter	32·9	25·0	17·4
Fixed carbon	64·1	54·7	39·3
Ash	3·0	20·3	43·3
	100·0	100·0	100·0

The extent of the coal formation has not yet been definitely ascertained, but is now being examined. Most of the coal of this field is open-burning, although some of it will coke, giving a product of inferior quality. The total production of coal in Sweden for 1873 was only 2,238,032 cubic feet, of which 1,718,346 cubic feet came from the Höganäs mines. The total quantity is not one-eighth of that imported into the country, and its consumption is very limited.

Russia.

This country exhibited quite an extensive suite of samples of coal, both anthracite and bituminous, and accompanied for the most part by analyses, furnished by the Russian Mining Bureau.

The administration of the mining district of Western Poland exhibited specimens of coal belonging to the Trias and Jura formations. Some of the coals coke, others do not. No analyses were furnished.

A much larger suite of coal was exhibited from the most southern province of Russia (the Government of Taureda), the analyses of which show that the greater portion of them are semi-bituminous. As is seen from the analyses, they are all very low in sulphur and ash, appear to be of a good quality, and are well adapted for iron-smelting.

I. From the Volyntzowskaja Pit, belonging to Princess Dolgoruky, on the right bank of the Bulawin River; the seam is 4½ feet thick.

II. From the Golubowskaja Pit, belonging to the Dessemon Company, on the left bank of the Lugani River. There are two beds, each 2 feet 4 inches thick.

III. From pits belonging to Nestroff & Smoljaninoff, on the right bank of the Calmius River. The coal-bed is 3½ feet thick.

IV. From the Alexandrowskaja Pit, belonging to Prince Liven, on the right bank of the Calmius River. The bed is 6½ feet thick.

There was also a specimen from the Inow Pit, on the left bank of the Olchowaja River, where the bed is 2 feet 4 inches thick.

	I.	II.	III.	IV.
Volatile matter	12·64	37·95	16·50	29·00
Fixed carbon	86·04	61·21	82·63	69·92
Ash	1·32	0·84	0·87	1·08
	100·00	100·00	100·00	100·00
Sulphur	0·80	0·35	0·24	0·36

None of the coal-beds represented appear to be of very great thickness, and some of them so thin that, unless suitable labour can be obtained very cheaply, it seems rather doubtful whether they can be profitably worked.

New Zealand.

A very fine suite, showing the coal resources of this British colony, was displayed by Dr. Hector, Director of the Geological Survey; exhibits were

also made by the Parapara Coal Company, Kennedy Brothers, Albion Coal Company, and the Nelson Committee. All of the exhibits came from the Province of Nelson, in South Island, and are of Mesozoic age. Dr. Hector's exhibit consisted of various specimens. The first was a caking coal, from the Brunner Mine; it is tender and friable, but cakes strongly, the best variety forming a vitreous coke, with a high metallic lustre. It is stated that in average samples of the coal one pound of it will evaporate 7·5 pounds of water. The beds of this mine are 2 to 20 feet thick.

A specimen of semi-bituminous coal was exhibited from Pakawau, which is said to be either non-caking or to cake together moderately.

The Parapara Coal Company exhibited a block of coal taken from a bed 3 feet thick, said to represent the general quality of the coal-field. The coal occurs in a mountain range on the north bank of the Aorere River, the mine being worked by a drift in the hill-side, about 800 feet above tide. This drift has cut through five coal-seams, varying from 18 inches to 3 feet in thickness, the whole giving 6 feet of workable coal. In the British Catalogue it is claimed to be unsurpassed in New Zealand for gas purposes, to be an excellent household fuel, and very superior for steam use.

The Albion Coal Company exhibited a block of coal from Ngakawau. The bed, said to be 10 feet thick, ascends from the sea-level to an elevation of 1,400 feet in Mount Frederic range, 20 miles north of Westport, with which the mine is connected by railway. The appearance of the coal was fair.

Kennedy Brothers exhibited specimens of coal and coke from the Brunner Mine, which is situated on the Grey River, seven miles from the port of Greymouth. The bed worked has a uniform thickness of 16 feet, all pure, clean coal. This coal is said to be eagerly sought after in the colony for gas and foundry purposes. Engineers of local steamers prefer this coal for steam purposes to that from New South Wales. The coke, already mentioned, does not look to be of a first-rate quality, and is rather friable.

The Nelson Committee exhibited blocks of coal from Reefton and Coalbrook Dale, Mount Rochfort. At the latter point there are two coal-seams, 8 feet and 18 inches thick, at an elevation of 2,200 feet above the sea. The coal was fair in appearance.

It is much to be regretted that no analyses of the New Zealand coals were furnished from which some idea of the actual value of the coals could be ascertained.

Australia.

There were exhibits from several of the British Australian colonies.

Queensland.

While coal belonging both to the Mesozoic and Carboniferous periods occurs in this colony of Great Britain, only that belonging to the former appears to be worked and was represented at the Exhibition. According to Richard Daintree, the coal-beds of the Carboniferous are in many cases of a fair thickness, and there appear to be many of them; but their exploitation, if carried on at all, appears to be but small, and must be confined to mere local use. Exhibits of coal were made from the Mesozoic coal-basin, which extends from Ipswich, on the Brisbane River, to the coast.

Samples of coal, in some cases several feet in size, were exhibited from the Tivoli Mine, two miles from Ipswich; the Aberdare Mine, five miles from the same; the Allora Mine, one mile from Allora; the Flagstone Creek Mine; the Rosewood Mine; Bengera Mine; the Clifton Mine; Perseverance Mine, at Ipswich; Blackfellow's Creek, near Galton; Warwick; and by W. R. Alexander. Gullard & Co., who own the Tivoli Mine, exhibited with the coal the coke made from it. The coal occurs here in a bed 3 feet thick, and presented a very good appearance, as did the coke made from it. The latter, although inferior to Durham and Connellsville coke, was firm and strong, and appeared to be well adapted to use in the blast-furnace for iron, tin, and copper-smelting. The following analyses were attached to the specimens:

I. Coal.		II. Coke. I.	II.
Moisture		1·14	1·14
Volatile combustible gases	H	5·19	30·02
	O + N	6·56	
Fixed carbon		79·01	coke 68·84
Ash		7·73	—
Sulphur		0·37	—
		100·00	100·00

This coal, from the analysis, is semi-bituminous in character, and better adapted for making coke and for raising steam than for other purposes.

The coal exhibited by W. R. Alexander is taken from a mine thirty-one miles from Brisbane. The bed is said to be but 1 foot thick. Neither the coal nor the coke made from it presented a favourable appearance; the latter not appearing firm nor of a special quality. Analyses attached to the specimens gave (I. being the coal, II. the coke):

		I.	II.
Moisture		1·92	1·92
Volatile combustible matter	H	6·34	47·73
	O + N	9·08	
Fixed carbon		68·28	coke 50·35
Ash		13·98	—
Sulphur		0·40	—
		100·00	100·00

The percentage of ash is nearly double that of the preceding coal.

The remaining specimens were without analyses, but in their appearance resembled that from the Tivoli Mine.

New South Wales.

Specimens of coal were exhibited from each of the four principal coal-fields, and also specimens of coke; the whole being displayed by the Department of Mines. The Lithgow Valley Iron and Coal Company also exhibited coal. No analyses accompanied the specimens, which is the more to be regretted, as this colony contains mines more developed than any other in Australia.

Victoria.

Two specimens of coal were exhibited from this colony of Great Britain, but without any localities or facts being furnished. It was impossible from these to form any opinion as to their quality.

Tasmania.

There were three exhibits of coal from this colony of Great Britain. Frederick Groom exhibited a specimen from Harefield, near Fingal, in Cornwall; James Harcourt, from Leymour, in Glamorgan; and Lyell & Gowan, from the river Don. No proof of quality by analyses or otherwise were furnished, and it was impossible to determine the quality from the specimens exhibited. The coal mined is almost exclusively used for domestic purposes, and the quantity is small, as a good deal of this fuel is annually imported from New South Wales.

India.

The India Museum sent from its collections specimens of coal from the Nerbudda Coal & Iron Company's mines.

Japan.

No analyses of the specimens of coal were furnished, and it was impossible to determine their quality from an examination of those displayed. The following information is derived from the Japanese Sectional Catalogue:

Mineral fuels are found in numerous places, and have been worked in small quantities for many years, their use being confined to the salt-works, lime-kilns, and occasionally blacksmiths' forges. The most important coal-fields are those in the north-west of the island of Kiushiu, in the district of Karatsu; and also in the island of Takashima, near Nagasaki. When the American steamers commenced running between China and Japan, they generally provided themselves at Nagasaki with Karatsu coal. This fuel is found in a sandstone formation, frequently broken through by granitic dykes. The beds appear on hill-sides, are at the most 5 feet thick, and are composed of alternate layers of coal and slate, the thickness of the former varying from a few to 20 inches in the best places. The total yield of the Karatsu district may be estimated at 80 to 90 tons daily.

The development of steam navigation soon demanded a larger supply of fuel, and the working of the rich seams in the island of Takashima, about eight miles west of Nagasaki, was then commenced on modern systems with improved machinery. This mine produced 78,000 tons in 1874. The seams, having a dip of some 20° from south to north, are thirteen in number, varying from 3 feet to 10 feet in thickness; but only five of them yield a good quality of coal. The work was commenced in 1863, by the sinking of a shaft in the northern part of the island down to the second bed, which was 8 feet thick, and was worked out in 1875. A second shaft, more to the south, has been sunk to the lowest strata, where two good seams of 8 and 10 feet thickness are found lying above one another, with very little barren measures between them. In addition, a little below half-way down, the shaft transverses another bed, 5 feet thick, of a coal of good quality. The daily production at this shaft is 650 tons. The produce is composed of 60 per cent. of small coal, quite good enough for steamers. The coal is of a good quality, containing only 5 to 7 per cent. of ash, of a caking quality, and giving an excellent coke, and is fit for any industrial purpose. There is now a working population of 1,500 miners, and 200 carpenters, blacksmiths, &c.

The exhibit was made by the Mining Department at Tokio.

III. Lignite.

The principal exhibit of lignite from the United States was made by the Commissioners of the State of Colorado. The lignite from the different coal-fields in this State varies very greatly, for while the greater portion contains too large a proportion of water to coke efficiently, that mined at Trinidad not only yields a coherent coke, but contains a sufficient quantity of hydrocarbons to be used in the gasworks at Denver. The question of obtaining a coherent coke, if possible, from some of the Western lignites is a matter of great importance in the development of the smelting operations on the gold, silver, lead, and copper ores that are being so extensively mined; the more so when it is borne in mind that coke is shipped all the way from Pittsburgh, Pennsylvania, to Utah to be used in the smelting-works. Nor can this question cease to become constantly a more urgent and pressing one in proportion as the scanty supply of wood in the West becomes exhausted without being replaced. Nor is it confined to this alone when we think of the large consumption of coal necessary for blacksmithing and foundry use, which becomes a factor of some importance if it has to be transported 2,000 to 3,000 miles. At present, however, experiments are being made at several points to determine the value of these lignites, and until their conclusion it is premature to speak of their possible future value for metallurgical purposes. One great defect which they all labour under is the great tendency to fall to pieces when at all exposed to the weather, while many of them also decrepitate on exposure to heat.

The Geological Survey of Canada exhibited specimens of lignite from the Saskatchewan River and Vancouver's Island. The former may in time prove

of some importance for domestic consumption, but will probably never be used for other purposes. The Vancouver's Island lignite will very probably prove of some little importance for the residents of British Columbia for household and steam purposes, but unless, as the mines are extended, the quality of the coal improves and it is found possible to coke it, the demand will always be a limited one.

Dr. Hector, of the Geological Survey of New Zealand, exhibited specimens of lignite, showing the transition from the true lignite through bituminous to anthracite coal, which were very interesting. J. J. Oakden exhibited a specimen of anthracite coal from Lake Coleridge, Province of Canterbury. There are said to be two seams, each 5 feet thick, and the extent of the coal-field is supposed to be but 100 acres. The coal contains 90 per cent. carbon.

Alexander W. Reed exhibited a specimen of altered lignite from Kowai Pass, Province of Canterbury, taken from a bed 3 feet thick.

No idea of the economical value of these New Zealand lignites could be obtained from the specimens exhibited.

A few small specimens of lignite from Russia were also exhibited.

In concluding this report the author desires to acknowledge the obligations he is under to Professor E. T. Cox, State Geologist of Indiana, Messrs. C. J. Norwood, A. R. Crandall, and J. R. Procter, of the Kentucky Geological Survey, and Mr. William Gesner, of Birmingham, Alabama, all of whom have furnished him with valuable information; as also the geological reports of many of the States and of Canada.

BUILDING AND ORNAMENTAL STONES,

By J. S. Newberry.

The display of building and ornamental stones in the Centennial Exhibition was exceedingly rich and varied, probably far more so than is generally supposed, from the fact that the exhibits were very much scattered.

The principal collections of building-stones were in the mineral annexes to the Main Building and in the Government Building; but very imposing arrays of materials used in construction were shown in the English, Japanese, Swedish, Portuguese, and Spanish departments, and in several of the State buildings. Among the latter were some that deserved special notice, viz., the coloured marbles in the Maryland Building, and the freestones in those of West Virginia, Indiana, and Ohio. A creditable display was also made in the Kansas and Colorado Building.

Of stones used in construction alone there were more than five hundred exhibits, and of ornamental stones, including gems, at least as many more; but the latter were chiefly included in collective exhibits, and are not specifically mentioned in the catalogues or awards.

Most of the building-stones naturally came from our own continent, of which Canada and the Eastern and Middle States had the best representation. This was due chiefly to their proximity to the place of exhibition, to the density of population, the more thorough development of the mineral resources of this region, and the greater facilities for transportation, and not to the larger endowment of the eastern portion of the continent in materials adapted to the construction and ornamentation of buildings.. Most of the Western States and Territories abound in excellent building and ornamental stones, and they are destined to contribute largely in the future to the materials used by our people in the construction or embellishment of public and private buildings. As an illustration of the richness of some portions of the Western United States in the class of objects under consideration, I may say that during the exploration of the Colorado River, in which I was engaged under Lieutenant J. C. Ives, U. S. A., I collected and brought in something like two hundred varieties of porphyry, some of which equal in beauty and excellence any that have been found in other parts of the world. Granites, marbles, serpentines, jaspers, &c., are also known to exist in endless variety in the Rocky Mountain belt, and the mountains of California and Oregon. Scarce any of these were represented in the Centennial Exhibition; but we may confidently expect that they will form a conspicuous element in the

exhibitions of the future, which, following the flow of population and wealth, will be held in the more western seats of civilization.

Among the exhibits of building-stones which attracted and deserved special attention, was the rich and varied display of the Canadian Geological Survey, which in the variety and beauty of the materials, and the symmetry and good taste with which they had been prepared, excelled all other collective exhibits in the Exhibition. Aside from this collection of the Geological Survey, the Canadian exhibit included a fine suite of red granites in slabs, pedestals, vases, and monuments from the Bay of Fundy and from Forsyth's Island; also a large number of sandstones in dressed six-inch cubes from different localities, and larger dressed blocks from Shepody Mountain, Dorchester, and Cornwallis, and fine exhibits of slates from New Rockland, Melbourne, Ranklin Hill, and Danville, all of which will be more specifically mentioned farther on.

A very fine series of granites was sent from New England, including nearly every known variety of this stone, and constituting a collection such as has probably never before been gathered together. The chief localities from which these granites were sent are Hallowell, Fox Island, Jonesboro', Rockland, and Blue Hills, Maine; Barre and St. Johnsbury, Vermont; Quincy, Massachusetts; Westerly, Rhode Island; and Mystic, Lyme, Stony Creek, &c., Connecticut.

Of white marbles, a magnificent display was made from the quarries in Rutland County, Vermont, almost the only place in the United States from which white marbles came to the Exhibition; but here they seem to be found in almost infinite variety and of excellent quality.

Coloured marbles were furnished from Swanton and Burlington, Vermont, and from Maryland and East Tennessee. Combining the large and varied exhibit from these localities, it was shown that the United States is as well endowed with this beautiful series of ornamental stones as any other country in the world, and that when the quarries in the districts I have mentioned shall be properly opened, the variegated marbles hitherto so largely imported from Europe will find formidable if not victorious rivals in our home products.

The display of freestones in the Exhibition far surpassed in number and variety that of any other group of building-materials, and included both sandstones and limestones, fitted to supply every want of the architect, and fully equal in beauty, strength, and durability to any that have been found and used in the Old World.

Allusion has already been made to the sandstones of Nova Scotia; beside these, we had from the Eastern United States a number of exhibits of the Triassic sandstones of the Connecticut Valley, New Jersey, and Pennsylvania. From the valley of the Mississippi came, however, the greatest contributions of freestones, since throughout hundreds of thousands of square miles it is underlaid by sedimentary rocks, in which limestones and sandstones occur in infinite variety. Ohio, Kentucky, and Indiana sent large and fine collections of limestones, varying in hardness and colour from pure white to dark gray and blue, and including many varieties of great beauty and of proved excellence. Limestones of peculiar and desirable qualities also came to the Exhibition from Indiana, Kentucky, Northern Illinois (the Athens marble), from Canton, Missouri, and from Central Kansas. The most important exhibits of sandstone were included in those of West Virginia and Ohio, while very different and remarkably good varieties came from Marquette, Michigan, and St. Genevieve, Missouri.

The American slates, of which there were more than twenty exhibits, with one exception, came from the metamorphic rocks which pass up through the Eastern States into Canada. Aside from the Canadian slates, to which reference has already been made, those of excellent quality came from Maine, Southern Vermont, Eastern New York, Eastern Pennsylvania, and Virginia. The only Western exhibit of slate was that from the Huron Mountains, on the south shore of Lake Superior. From these different localities slates of all varieties of colour and consistence were obtained.

The serpentines and verd-antique marble sent to Philadelphia by American exhibitors were all derived from the Atlantic belt of metamorphic rocks, in which the serpentines form a widely-diffused, though nowhere a preponderating element. These include all the varieties of this rock, the precious serpentine of Newburyport, the verd-antique marbles of Roxbury, Vermont, Milford,

Connecticut, Broad Creek, Maryland, and the massive and earthy serpentine of Hoboken, Brandywine, &c.

Of porphyries there were no exhibits in the American department except the small polished specimens of Messrs. Bouvé & Lovatt, of Boston. Among these there was, however, quite a variety,—some closely resembling the brown and red porphyries of Sweden and Italy, and others that were brighter and handsomer than these.

In the foreign exhibit of building-materials, the gray and red granites from Peterhead and Aberdeen, in Scotland, and the dark-gray granite of Bessbrook, Ireland, were most conspicuous for the magnitude and variety of the objects made from them, and the excellent quality of the stone and workmanship.

A large and interesting collective exhibit of the building-stones of Sweden was made by the Geological Survey of that country. This consisted of 176 specimens in six-inch cubes, handsomely polished, and formed by far the most complete and attractive series of building-materials shown by any foreign nation. Most of the specimens were of the crystalline rocks which compose the great mass of the Scandinavian Peninsula, and though of great interest geologically, have little claim to beauty as building-materials. To this rule, however, there were marked exceptions, in the porphyry of Elfdalen, the granites of Uddevalla, the gabro serpentine, metamorphic conglomerate, &c., which, however, were much more fully represented in the exhibits of private manufacturers, to be presently noticed. In the series of building and ornamental stones shown in the Swedish department, the conglomerate, referred to above, appeared in several forms. This rock is peculiar in appearance, and of special geological interest. It is a metamorphic conglomerate, in which the sand is converted into whitish quartzite, and the imbedded pebbles are largely composed of blood-red jasper. It takes a high polish, and from the contrast of colours it presents is quite handsome. It is further interesting from the fact that it is almost undistinguishable from a rock found in the Huronian of Canada, fragments of which have been scattered by drift agencies over the North-western States. The Swedish exhibit also contained a series of polished table-tops of fossiliferous limestone from Gotland, exhibited by J. W. Klintberg, of Wisby. The same material was also wrought into a great number of ornaments, such as brooches, cuff-buttons, bracelets, paper-weights, &c. The porphyry and conglomerate, which have been referred to, were also wrought into a great variety of ornamental objects, many of which were very handsome, but were more indebted for their attractiveness to the skill with which they were worked than to any inherent beauty of the material employed.

The marbles sent from Europe included representatives of nearly all the famous varieties used in ancient art or architecture, or known in modern commerce. From Belgium came the beautiful black, white, red, and mottled marbles which, wrought into mantels with artistic workmanship, excited the admiration of all visitors to the Belgian department. France sent no representation of the beautiful building-stones that are found within her territory; but some of the American workers in marble, as Fauchere & Co., of New York, exhibited very fine specimens of the most esteemed French marbles,—the Griotte, Campan, Sarrancolin, &c.

In the Portuguese department was a very extensive and interesting exhibit of building-materials, prepared with great care by the provincial officers in the different districts. Also a fine series of the coloured marbles from Oporto, Cintra, and Lisbon, including all the varieties which form the basis of the large export trade of this country in marble.

Spain contributed a full representation of her great and varied mineral wealth, which included a series of cut and polished marbles, serpentine, &c.

From Italy came a respectable collection of building and ornamental stones, but much less extensive than might have been expected from the country which has so long been the home and school of architecture, sculpture, and the decorative arts. Of wrought marble there was no lack in the Italian department, and the quarries of Carrara furnished the material of most of the sculpture shown in the Exhibition, but no other exhibit of the famous Italian statuary marble was made, while the coloured marbles, alabaster, and other ornamental stones were scarcely to be seen except in the material of manufactured articles. To this general rule there were, however, some striking

exceptions, such as the beautiful collection of marbles, alabaster, &c. sent by the Chamber of Commerce and Arts in Sienna, and the series of 100 pieces of ancient marbles gathered from the excavations at Rome.

Greece sent no building or ornamental stones to the Exhibition, and her famous Parian and Pentelic marbles were only to be seen in some antique sculptures and the patchwork of modern mosaic.

Of the Eastern nations, Japan alone made any effort to exhibit the materials used in construction. In the wonderfully comprehensive and admirable exhibit of this country, however, there was included a series of nearly 100 slabs of building stone, carefully dressed and polished. These represented a considerable variety of rocks, though few had any claim to beauty; yet the collection was of great interest as indicative of the geological structure of the country, and as showing the thoroughness and intelligence of the Japanese in their investigation into the useful qualities of such materials as they possess.

The Australian exhibit in all things gave proof of the enterprise, energy, and practical faculty of the English race who have taken possession of that continent. All the mineral resources of the country seem to have received attention, and many of them have been so far developed as to form the bases of flourishing industries and active commerce. Numerous specimens of building-stones, slates, &c., came from the different Australian provinces, but these were mostly of the useful rather than of the ornamental kind. Excellent granite and sandstones seem to be abundant, and beautiful malachite and opals were shown in the Queensland exhibit; but no fine marbles, porphyries, serpentines, or other ornamental stones were shown, leaving it to be inferred that they are less abundant in this than in most other great divisions of the earth's surface.

The building and ornamental stones of the continent of Africa had no other representation in the Exhibition than that afforded by a small collection of coloured marbles, mostly mottled red, shown by W. Struthers & Sons, of Philadelphia.

South America was but little better represented than Africa. A few specimens of marble and slate from Brazil, unattractive in colours and imperfectly wrought, and a small collection of building-stones from the Argentine Republic, containing nothing specially worthy of note, were all the mineral material used in construction furnished by this great continent. Of gems, ores, and crystallised minerals a very different story can be told, and it is evident that they monopolised the attention of those who were interested in gathering specimens of the mineral resources of South America. The diamonds, topazes, emeralds, and tourmalines of Brazil deserve a special mention, which they will have in another place.

From Mexico came, perhaps, the most beautiful ornamental stone shown in the Exhibition,—the so-called Mexican onyx (stalagmitic aragonite), from Tecalli, State of Puebla. From San Luis Potosi and Guanaxuato were sent several varieties of marble and sandstone, but none that require special notice.

This already somewhat long catalogue of foreign exhibits may appropriately be closed by a brief reference to the building-stones sent from the islands of New Zealand, Bermuda, and the Canaries.

The New Zealand collection was naturally the largest of these, and included blocks of white and yellow limestone from Christchurch, and marble from Ruatanuka and Collingwood, all of which were good and serviceable building-stones, but were without any special beauty or excellence that requires further notice.

From the Bermudas was sent the peculiar white porous limestone which constitutes almost the only rock known on the islands, and the almost universally used building material. Though surpassed in beauty and strength by most of the building-stones exhibited this material is of incalculable value to the inhabitants of the Bermudas, since it can be sawed or otherwise wrought almost with the facility of wood. It is clean and white in colour, and is hence admirably adapted to the construction of the sort of houses used in that subtropical climate.

From the Canaries was sent an interesting series of building-stones, all of igneous origin, the only rocks known in this volcanic group. The specimens were sent by E. Angel Gomez, and formed part of the Spanish exhibit.

The different classes of building and ornamental stones shown in the Exhibition will now be more definitely described under separate heads.

I. Granites.

In its popular acceptation the term granite includes several varieties of rocks which lithologists distinguish by different names, viz. :—

1. Typical granite, which consists of quartz, feldspar, mica, and hornblende.
2. Syenite, which contains no mica, and hence is the strongest and most durable variety of granite.
3. Gneiss, which is a stratified or bedded granite.

It should be said, however, that all these varieties shade into one another, and in the following notes all are included, except in certain specified cases, under the general term which, in commerce and architecture, is used to cover all the granitoid rocks.

Among all civilised nations granite has been extensively used for structural, monumental, or decorative purposes, chiefly from the possibility of quarrying blocks of it of any desired size, and from its great strength and durability. From the difficulty with which it is wrought into ornamental designs, its use has been restricted to structures of a more plain and massive character; yet, by the ancient Egyptians, it was not only very largely used for temples, pyramids, and obelisks, which, in their number and magnitude, constitute the grandest monuments of architectural art, but the polished surfaces of these structures were literally covered with deeply and accurately engraved hieroglyphics, sufficient in number to form an almost complete historical record of this long-lived and wonderful nation. Among the people of more modern times labour has become too valuable a commodity to be expended in carving this obdurate material, and most of the structures of the Greeks and Romans, and the nations of modern Europe, have been built of some more easily wrought and generally less sombre stone.

By the substitution of machine for hand labour, and by improved methods of cutting and polishing, granite has now come into more general use, and while the progress of democracy has dethroned the despots of the world, and has made it impossible that monuments like those of Egypt should ever again be erected, a more intelligent appreciation of the adaptation of granite to architectural and engineering work has caused it to be chosen for the most massive and permanent structures. The craving for immortality, common to all men, has also led to the erection of a thousand granite monuments to mark the resting-places of private individuals, instead of the single greater one raised by some ancient autocrat to perpetuate his fame, while the common people lived and died like the beasts that perish.

Granite is now used for several and quite different purposes. By far the larger part is employed for heavy and coarse masonry, docks, bridges, and foundations, while in many instances the superstructure of public buildings, and of the palaces that commerce erects, is composed of this material. The qualities of granite which fit it for such purposes — its strength and durability—are so marked as to give it superiority over every other stone in use. Good granite will bear a crushing force of from fifteen to twenty-five thousand pounds to the square inch, and the better varieties are among the most enduring of all rocks. In this respect, however, granites differ much among themselves. The constituents of granite are quartz, feldspar, hornblende, and mica, minerals of which the chemical composition and physical characters are very unlike. Mica is soft and fissile, and hence is an element of weakness. Where it exists in any considerable quantity the stone is easily crushed and unfit for use. The feldspars of granite are usually orthoclase (potash feldspar) or albite (soda feldspar), and of these the former is the most durable, but even this sometimes decomposes by the removal of its alkali, falling into a powder (kaolin); and it is not uncommon to find granite

deeply disintegrated over wide areas by this sort of decay, which Dolomieu calls *la maladie du granite*. The strongest and most durable element in granite is quartz, and, as a general rule, the resistance which the stone offers to violence and time will be measured by the proportion of quartz to the other elements. The hornblende of granite is a tough and durable mineral. When present in large quantity it gives weight and tenacity to the stone.

The chemical composition of an average granite is about as follows :—

Silica	70·00	Iron oxide	4·00
Alumina	14·00	Potash	6·00
Lime	2·00	Soda	2·00
Magnesia	1·00	Water	1·00

This is, however, but an imperfect guide in judging of the strength of the stone, the feldspar being a somewhat uncertain and treacherous element. The best evidence on the question of the quality of granite is afforded by its resistance to crushing force, which should be 15,000 lbs. or more to the square inch, and its porosity, or power of absorbing water. An average granite contains or will hold about one per cent. of water, and if its absorbent power is much greater than this, it shows that it is liable to be affected by the action of frost. If practicable, the natural outcrops of granite should be examined with a view to determine its durability. Where the rock which has been exposed for ages is found to be sound and strong at the surface, this affords conclusive proof of its durability.

The prevailing colour of granite is gray, which darkens by exposure,—chiefly from smoke and dust, which lodge in the irregularities of the surface,—and hence it is apt to become dull and sombre. For this reason, and to lighted up the massive style of architecture almost necessary from the toughness of the material, the lighter-coloured granites are to be preferred. For sepulchral monuments, for which granite is now much used, a red granite like those of Peterhead, Scotland, and the Bay of Fundy, is often preferred on account of its colour. When gray granites are used, the choice lies between a light stone, which when hammer-dressed is almost as white as marble, or one of darker gray, in which the polished surface, of much deeper tint, contrasts strongly with the engraved and hammered portions, thus bringing out distinctly inscriptions and ornamentation.

In the construction of buildings erected by the Government in the United States, a decided preference has of late years been given to granite; and in obedience to this taste, granite has sometimes been transported many hundreds of miles to localities where building-stones sufficiently durable, much handsomer, and very much cheaper could have been obtained.

In contrast with the many excellences which granite possesses it has one fault which should not be lost sight of, and that is, the readiness with which it is destroyed by fire. From the close texture of the stone it expands unequally when heated on the surface, and exfoliates, sometimes, with explosion. In this respect it is inferior to brick, sandstone, or even marble.

The granites exhibited at Philadelphia were for the most part those of established reputation, and such as had been demonstrated by use to be both strong and durable. It was not, therefore, necessary to go into any careful examination of these qualities. The diversities which they presented were chiefly such as pertain to colour and fineness of grain. In these respects they differ less than many other kinds of building-stone, and yet sufficiently to afford some room for the exercise of taste in their choice, and to determine their adaptation to the different purposes for which granite is used.

In colour the granites exhibited were referable to three groups, namely, the red, the light gray, and the dark gray, typified by the Bay of Fundy, red, the Thomaston, light, and the Quincy, dark.

The number of granites which would be classed as gray in colour—that is, having a fine or coarse mottling of black and white, or a blending of black hornblende with gray, blue, or greenish feldspar—was very large; so large that only a few can be noticed here.

Most of the granitoid rocks (granites, gneisses, and syenites) of Canada, New England, and the Alleghany belt are grayish in colour; and almost every county underlaid by metamorphic rocks on the Atlantic coast can

furnish several varieties of what would be, in popular language, called gray granite.

In the Rocky Mountain belt, red granites are much more abundant, and in places form the prevalent rocks over hundreds of square miles.

In the Sierra Nevada again, light-coloured granites prevail, almost to the exclusion of red. This difference is occasioned by variations in the quantity of iron contained in the feldspar,—which constitutes the most abundant ingredient in all these rocks,—and in the relative proportions of albite and orthoclase.

In the notes which follow, the principal exhibits of granite in the Centennial Exhibition are briefly described in order; first, those of the United States, and afterwards those sent from foreign countries.

Maine Granites.

As the quarries of Maine have hitherto been the chief source of the supply of granite to the principal cities of the United States, and this is practically, though not nominally, the granite State, the granites of Maine may properly first engage our attention.

Not all of the well-known granites of this State were represented in the Exhibition, but the following list will be found to contain most of those that have up to the present time been produced in any considerable quantity, either for home consumption or exportation:

1. Calais Red Granite, exhibited by *The Maine Red Granite Company.*

In the Main Building were shown a block and column of the Calais red granite, a stone already well known in the markets of the Eastern States. It is composed of pale-red orthoclase, with a smaller quantity of a lighter feldspar, possibly albite, with quartz, hornblende, and a little mica. It takes a fine polish, is homogeneous in texture and colour, and well deserves the good reputation it enjoys.

2. Red Granite, Red Beach, exhibited by *The Hinsdale-Doyle Granite Company.*

This is a fine-grained granite, of which the general complexion is reddish, but less positively so than that of most so-called red granites. It is composed of pale-red and creamy-white feldspar, with smaller masses of smoky quartz, fine grains of black hornblende, and specks of black mica. It takes a good polish, and is undoubtedly a strong and durable stone. In quality it will take equal rank with the Jonesboro' and Calais red granites, from which it differs chiefly in its greater fineness of mottling. It comes from the same deposit but not from the same quarries as the last.

3. East Blue Hills Granite, exhibited by *The Collins Granite Company.*

This is a light-gray, coarse-grained stone, handsomely mottled and highly polished.

4. Blue Hills Granite, exhibited by *M. K. Chase.*

A pedestal was exhibited wrought from this stone, which is of light-gray colour and good texture.

5. Morgan's Bay Granite, East Blue Hills, exhibited by *The Morgan's Bay Granite Company.*

The stone from these quarries is a compact homogeneous, light-gray granite, composed of relatively large crystals of white orthoclase, with fine grains of glassy quartz and specks of black mica. In colour it is one of the lightest of New England granites, and from the preponderance of feldspar, the absence

of hornblende, and the granular condition of the quartz, it will work with unusual facility, and will prove a handsome and durable stone. From some experiments made upon it at the School of Mines, it was found to bear a crushing force of 17,200 pounds to the square inch. Its weight is 166·5 pounds to the cubic foot, and its porosity is ·233 per cent. of its weight,—that is, when dry, it absorbs less than half a pint of water to the cubic foot.

6. Harbor Granite, Fox Island, exhibited by *The New England Granite Company.*

This is a coarse-grained, handsome, mottled granite, composed of very pale-pink and white feldspar, mingled with relatively fine grains of quartz and hornblende. Its general tone of colour is reddish-gray blotched with white, and quite pleasing to the eye. It takes a good polish.

7. Hallowell Granite, exhibited by *The Hallowell Granite Company.*

The granite from the Hallowell quarries has been long and favourably known. It is a very light, fine-grained stone, consisting chiefly of white orthoclase feldspar, with relatively fine grains of glassy quartz, specks of black hornblende, and minute scales of silvery mica. This latter gives the stone a peculiar glitter, and adds greatly to its beauty without seriously affecting its strength. Dressed surfaces are almost as white as white marble, and where polished, the spangles of mica buried beneath the surface reflect the light and sparkle like diamonds. From the small quantity of quartz and the presence of mica, the Hallowell granite works with unusual facility, both in the quarry and under the chisel, yet it takes a good polish, and is as strong, and will prove as durable, as most of the esteemed varieties of this stone. It is said that blocks of sound granite have been taken from the Hallowell quarries weighing more than one hundred tons each. These quarries are situated in a ridge running north east and south west, rising about four hundred feet above the Kennebec River. The rock is really a gneiss, but its stratification is not visible in the blocks quarried for market.

8. Hurricane Island Granite, exhibited by *Davis Tilson.*

The exhibit of this stone was small, consisting of wrought and polished gray granite of good quality.

9. Spruce Head Granite, exhibited by *The Hinsdale-Doyle Granite Company.*

This stone comes from the Spruce Head quarries, near Rockland. It is a clean, mottled, white and black syenite, which consists of nearly equal parts of snow-white orthoclase, glassy quartz, and black hornblende. The constituents are firmly united, making it a strong and durable stone, which takes a brilliant polish. The quantity of hornblende in it, and the striking contrast in colour between this and the feldspar, give it a peculiar, bright, lively tint, which renders it one of the handsomest of the gray granites shown in the Exhibition.

10. East Boston Granite, Fox Island, exhibited by *The Hinsdale-Doyle Granite Company.*

This is a very fine-grained stone, having the general complexion of the Westerly granite, but differing from that by showing a faint pinkish blush in its feldspar. In this respect it resembles the Harbor granite of Fox Island, of which it is indeed only a fine-grained variety.

Excellent gray granites are quarried on Clark's Island, Dix Island, and Mount Desert, but they were not represented in the Exhibition. Very fine displays of the Maine granites wrought into monuments were made by the New England Granite Company, the Hinsdale-Doyle Granite Company, the Maine Red Granite Company, &c.

New Hampshire Granite.

From the "Granite State"—New Hampshire—no specimens of granite came to the Centennial Exhibition, though excellent varieties, and these of very varied colour and consistence, are known to exist in different localities in the State.

Vermont Granites.

Three exhibits of granite were made from Vermont, namely, a monument and tablet by the St. Johnsbury Granite Company, and cubes of granite by J. E. Parker, of Barre, and E. Kitteridge, of Bethel.

Of these, the St. Johnsbury granite, being all wrought, was examined by the Judges of another group. It is a gray stone, of excellent quality and established reputation.

The specimen of Bethel granite shown was nearly white,—lighter, indeed, than any other granite in the Exhibition. It seemed to be of a homogeneous texture, but was not highly polished. It must be an admirable stone for special uses, but it is possibly less durable than some of the more silicious and compact varieties.

The Barre granite enjoys a high reputation in the State, and has been used for the two public buildings at Middlebury. It was inadequately represented by the exhibits made at Philadelphia, but has been proved by ample trial to be an excellent stone for architectural and monumental purposes. It is light gray in colour, of medium fineness, very homogeneous and firm.

Massachusetts Granites.

From Massachusetts were sent a large number of exhibits of granite, but these were mostly wrought, and were intended rather to display workmanship than the quality of the material. These exhibits were made by Alexander Macdonald, and Scorgie, Wright, and Co., of Cambridge; the former showing a carved marble tree-trunk, with ferns wrought with much care and skill; the latter a finely wrought granite fountain, which demonstrated the tenacity and homogeneousness of the material, and the possibility of its employment for the most elaborate ornamentation.

The most varied and satisfactory display of Massachusetts granites was made, however, in the collective exhibit of the Smithsonian Institution, and the wrought granite work of the New England Granite Company. These included the gray granite from Cape Ann, and three varieties of the Quincy granite, all of which possess much beauty and excellence. The Quincy granite is so well known that a detailed description of it would be superfluous. In lithological character it is a typical syenite, consisting of quartz, feldspar, and hornblende, without mica. The colour varies considerably, and affords opportunity for the exercise of taste in combination and adaptation to different purposes. The variation of colour is due to differences in the feldspar of the different beds. In one it is pale green, in another purplish-blue, and in the third pale pink. The black hornblende, which exists in considerable quantity, is the same in all, as is also the glassy quartz. The stone is susceptible of a high polish, and its strength and durability are amply attested by the trials to which it has been subjected. As a whole, the Quincy granite is rather sombre in tone, and on this account is for many purposes less desirable than the lighter varieties. Handsome pedestals of Quincy granite were shown by Wm. H. Mitchell, the Concord Granite Company, and Henry Barker and Sons, all of Quincy, Massachusetts.

Connecticut Granites.

The granites of Connecticut were represented by a large number of specimens in the Exhibition, though most of the exhibits were small. These will be briefly noticed in succession.

1. Thomaston Granite, exhibited by *The Plymouth Granite Company.*

Two cubes of this granite were shown in the Smithsonian collection. It is the lightest in colour of all the granites exhibited at Philadelphia, is fine-grained, compact, and homogeneous, and is a remarkably beautiful and excellent stone, specially adapted to monumental work, for which it is largely used and highly esteemed.

2. Millstone Point Granite, exhibited by *J. B. Palmer and Co.*, and *Warren Gates' Sons.*

Cubes of dark gray granite, of fine homogeneous texture, showing strong contrast of colour between polished and dressed surfaces, sent from Millstone Point, were shown in the Government Building.

3. Leet's Island Granite, exhibited by *Beattie and Dresser.*

Of this granite two cubes and one column were shown. It is a reddish gray, rather coarse grained gneiss; a handsome building stone, but taking an imperfect polish, and is not well adapted to ornamental purposes.

4. Stony Creek Granite, exhibited by *F. W. Redpath* and *Green and Son.*

The granite from the quarries of Mr. Redpath is pale red in colour, of medium grain, and consists of flesh-coloured orthoclase, greenish white oligoclase, and glassy quartz, with specks of black hornblende and magnetic iron. Minute points of pyrites may also be sometimes seen in it. It is a strong, compact, and handsome stone, having an agreeable tint, taking a high polish, and has been proved by trial to be well adapted for both construction and ornament. Though but recently introduced into market, it has become quite popular, and is the material selected for the monolith columns of the new capitol at Albany, New York, the shafts of which are four feet in diameter at base, twenty-one feet high, weigh twenty-five tons, and cost ten thousand dollars each.

The granite from the quarries of Green and Son is a gray fine-grained stone of good quality.

5. Mystic Bridge Granite, exhibited by *The Mystic Granite Company.*

Two blocks, one light, the other dark, of this very fine-grained gray granite were exhibited; both homogeneous in texture, and handsome.

6. Umpewang Granite, Norwalk, exhibited by *Price, Bates, and Co.*

This is a rather fine-grained, pinkish gray granite, homogeneous and compact; a good building stone.

7. Lyme Red Granite, exhibited by *Prof. E. E. Salisbury.*

This stone comes from the quarries of Judge McCurdy, at Lyme. The specimens exhibited were from near the surface, and somewhat weathered, hence may not represent its normal texture. It is a very coarse-grained syenite, composed mostly of pale red or flesh-coloured feldspar, mottled with a whiter variety, and glassy quartz; it is also specked and streaked with hornblende. From the preponderance of coarsely crystallized pale red orthoclase in its composition, it has a more uniform tint than any other red granite shown in the Exhibition, and on this account, should it prove sound and strong, it will be a valuable addition to the varieties now in use for architectural and ornamental purposes.

Rhode Island Granite.

The only granite from Rhode Island was that from the famous quarries at Westerly, exhibited by the New England Granite Company. This is a remarkably fine-grained homogeneous stone, chiefly composed of pale pinkish or brownish white orthoclase and thickly set with minute grains of black hornblende, and occasional specks of black mica. It takes a fine polish, and is justly esteemed as one of the best granites in the country. The typical character of the Westerly granite was shown in a polished slab, four by eight feet surface, and three inches thick. Three cubes were shown by the same exhibitors, of which one was of a decidedly pinkish colour, the others fine and coarse grained gray granite, all of good quality.

New York Granite.

From the State of New York but a single specimen of granite reached the Exhibition. This was a red granite from St. Lawrence County, contained in the collective exhibit—chiefly Maine and Quincy granites—of Struthers and Son, Philadelphia. These specimens showed a defective polish, apparently indicative of an imperfectly homogeneous texture.

Maryland Granites.

A handsome display of granites from this State was made by M. Gault and Son, Baltimore. This consisted of, 1, a fine-grained gray granite from near Woodstock, Baltimore County; 2, a coarse-grained gray granite from Port Deposit; 3, a dark, mottled stone, with large spots, from Western Maryland; 4, a light pinkish-gray, rather coarse-grained, handsome granite from Guildford, Howard County.

Western Granites.

From the Western States it was not to be expected that much granite should be sent to the Exhibition. There were two exhibits, however, from beyond the Mississippi River which deserve notice. One, of the Ozark Granite, a dark red, rather coarse, but compact stone, which takes a good polish, and is evidently strong and durable. This was sent by P. W. Snyder, of the Ozark Granite Works, which are located near Iron Mountain, Missouri. The other exhibit, consisting of five blocks of dressed granite, was sent by H. D. Gurney, of St. Paul, Minnesota. Of these two were gray, two reddish, and one intermediate in colour. The tint of the reddish stone is rather dull, and the grain coarse, but all the specimens shown were apparently of good quality.

A beautiful red granite—the handsomest in the Exhibition—was contained in the collection of the Geological Survey of Wisconsin, and was brought in by an exploring party from the Laurentian area of the central part of that State. It is chiefly composed of red, almost scarlet, orthoclase, with small grains of quartz and hornblende. It is a very homogeneous and compact stone, taking an unusually perfect and brilliant polish, and was generally conceded by those who examined it to be the most beautiful granite they had seen.

Canadian Granites.

In the Canadian department there were a number of red granites which seemed to be of good quality, two of which were represented by large objects of different kinds, which fully illustrated the characteristics of the material. These were:

1. Red Syenite from Forsyth's Island, exhibited by *Robert Forsyth, of Montreal.*

This island is in the St. Lawrence River, near the village of Gananoque, and hence the stone is known in market as the Gananoque granite. The exhibit consisted of a monument and pedestal, and two large vases, all handsomely

wrought and highly polished. There were also exhibits of dressed stone and paving-blocks of the same material. This consists of bright-red orthoclase feldspar, bluish-gray quartz, with a little greenish-black hornblende, and occasionally some mica. Though less bright in colour than some of the Bay of Fundy granite, the Gananoque stone is of a pleasing tint, very homogeneous in texture, and takes an excellent polish. It closely resembles much of the Scotch red granite, and is apparently fully equal to it in all good qualities.

2. Bay of Fundy Red Granite, exhibited by *The Bay of Fundy Red Granite Company.*

This stone was shown by a polished monument three feet two inches square at base and fifteen feet high, four polished headstones, and two urns. The Bay of Fundy granite is already well known in the markets of the Atlantic Coast. It contains almost no mica, and therefore may be properly classed as a syenite. It is of moderately fine grain, the ground work composed of a bright light-red orthoclase, mottled with perhaps one-fourth of the quantity of bluish quartz and one-tenth or less of black hornblende. It is a very tough and compact rock, and takes as high and uniform a polish as any other variety of granite known.

3. Red Syenite from Kingston, Ontario, exhibited by *Hon. John Young, Montreal.*

The specimens of this stone shown in the Canadian Exhibit were comparatively small, and hardly afforded material for fully deciding on its relative merit. Though less attractive than the last mentioned, it is apparently a good and handsome stone, and is said to be obtainable in unlimited quantity, and in blocks of any desired size, from the harbour of Kingston.

In the Canadian department were also shown a number of gray granites, some of which were apparently of excellent quality. All these were, however, represented by small specimens, and their characteristics could therefore not be well judged or compared.

The granites of Canada are of several geological ages,—those from the north side of the St. Lawrence being chiefly Laurentian, both red, and gray; those on the south side chiefly metamorphosed Silurian and Devonian rocks. Of the New Brunswick granites, the gray are supposed to be lower Silurian and the red Devonian. In the latter group comes the Bay of Fundy granite, while the red granite of Forsyth's Island, as already stated, is Laurentian.

Scotch Granites.

The display of foreign granites in the Exhibition was quite large and varied. Some of these have been briefly alluded to in the preliminary sketch of the building-material shown in the Exhibition; but, as many of them are already sold in our markets, they deserve to be more specially noticed and compared than they have yet been.

The well-known red granite from Peterhead, and the gray, of Aberdeen, Scotland, were shown in a great variety of forms and by numerous exhibitors at Philadelphia. The most imposing displays were made by McDonald, Field, & Co., and James Hunter, Aberdeen, and by the Great North of Scotland Granite Company, Peterhead. These consisted of shafts, monuments, slabs, urns, &c., in great variety, and all showing excellent workmanship. Smaller exhibits were made by Hugh Campbell & Son—red granite from the Moor quarries, Newry,—and by R. Cruikshank and Co., of Glasgow.

The Scotch granites are justly esteemed for their beauty of colour, and closeness and uniformity of texture. They are now largely imported into this country, chiefly for monuments, which may be seen in every considerable cemetery between the Atlantic and the Mississippi. The red is the more largely used, being preferred on account of its colour. The popularity of the Scotch granites, excellent as they are, is not due, however, to any superiority over the granites of the United States, but rather from their early occupation and subsequent possession of the market. No stronger or more durable stone is likely to be

found anywhere than the granites of Peterhead and Aberdeen, but they do not surpass in beauty or excellence the red granites of the Bay of Fundy and Gananoque, and the more esteemed varieties of red and gray granite from New England. The Peterhead granite is composed of pale-red orthoclase, a little greenish albite or oligoclase, with much smoky quartz, and some black hornblende. No mica was found in the specimens examined, though a little is sometimes contained in the rock. It weighs 165 pounds and 14 ounces to the cubic foot.

Irish Granite.

A very handsome exhibit of blue and gray granite in headstones, monuments, &c., and polished columns and pilasters for building, was made by the Bessbrook Granite Works, of Bessbrook, Ireland. This stone is darker and more bluish in colour than the Scotch gray granite, and on this account will commend itself to some tastes. It is a close, compact stone, which takes a fine polish, and will doubtless prove very durable.

Swedish Granites and Porphyries.

The Swedish department contained two exhibits by private persons, which attracted much attention from the magnitude of the masses shown, the beauty of the material, and the fine workmanship which they displayed. These were made by Gottfried Berg, of Stockholm, and C. A. Kullgrens (widow), of Uddevala. Of these exhibits, the first consisted chiefly of polished porphyry objects, one of which was a portion of a column, of which the section was some two and a half feet in diameter by six feet in length. There was also a beautiful inlaid table of red porphyry, of which the price was $7500. This porphyry comes from Elsdalen, in Dalecarlia, and is well known in the markets of Europe. It consists of a dark-red or brownish base, with small, whitish crystals of feldspar, and very much resembles the antique red porphyry so largely used by the Romans. It is undistinguishable from some of the porphyries of Eastern Massachusetts, of which specimens were shown in the collection of Mr. T. T. Bouvé, in the Government Building.

The exhibit of the widow Kullgrens consisted mainly of granite or syenite in shafts, monuments, and polished slabs. Considerable variety was shown in the texture and colour of the stones, but most of them were fine-grained and of dark colours. The material of the columns resembled somewhat the granite of Westerly, Rhode Island, but was darker. A monument, seven feet in height, was of dark, fine grained granite, and most beautifully wrought and polished. The slabs, of which there were eight, three by one and a half feet in surface, were of three kinds, all dark, but so highly polished as to be very handsome.

II. Freestones.

The term freestone is used in the Eastern United States to designate sandstones and limestones, and was adopted because they are wrought with so much more facility than the crystalline rocks of New England and the Alleghany belt. As has been mentioned, the display of this class of building stones in the Exhibition was very large, especially of sandstones, of which a great number of exhibits were made by several Western States. These differ much among themselves, both in colour and texture, but form four groups, distinguished by their geographical distribution and by their physical characteristics. These are, first, the olive-green sandstones of Nova Scotia, of Carboniferous age; second, the brown Triassic sandstones of Connecticut, New Jersey, &c.; third, the drab and dove-coloured stones of the Waverly and Coal-Measures of Ohio and West Virginia; fourth, the purplish-brown Potsdam sandstones of Lake Superior.

Taken as a whole, the sandstones constitute by far the most varied and valuable group of building-stones which we possess. Their good qualities are manifold. When freshly taken from the quarries and saturated with the solution of silica, which is called the quarry water, they are wrought with the

greatest ease, while they subsequently harden, and become almost indestructible by any agent except mechanical violence. They are also very resistant to fire, and finally, they exhibit such a diversity of tint and texture that they afford the architect great range for the exercise of taste. For these reasons as well as their wide distribution, and the cheapness with which they can be furnished to all our markets, they are more extensively used for construction than any other building-material, except brick and wood.

Canada Freestones.

The Canadian department contained a large number of cubes of dressed sandstone and limestone, most of which formed part of the splendid collective exhibit of the Geological Survey. Among these were several which were apparently of excellent quality and of good colour; but none afforded adequate opportunity for judging of their merits.

The Dorchester Stone, or, as it is better known in the market, the "Nova Scotia stone," was represented by a number of exhibits, which afford good illustration of the characteristic qualities of this excellent building-material. These were from the Hopwell Quarry Company, whose quarries are situated on Shepody Mountain, Hopewell, Albert, New Brunswick; the Caledonian Freestone Company, and the Dorchester Union Freestone Company, of Dorchester, New Brunswick. The stone is derived from the millstone grit formation, is pale olive-green in colour, of medium fineness, uniform texture and tint, and of good strength. It has been proved by extensive use in the Atlantic States to be a durable and serviceable stone, and is generally admired for its colour.

Eastern United States Freestones.

The Brownstone of the Eastern States was represented by specimens exhibited by Norcross Brothers, East Longmeadow, Massachusetts; Shaler & Hull, and the Portland Brownstone Quarry Company, of Portland, Connecticut. The stone shown by all these exhibitors was similar in character, and especially the display made by the Portland Brownstone Company illustrated well the prevailing character of this largely-used and highly-esteemed stone. As is well known to all who are familiar with the Triassic sandstones of Connecticut and New Jersey, they vary much in quality, and need to be selected with much care. Some of the varieties are laminated in structure, and hence are liable to exfoliate, especially when used as ashlars and set on edge. Others, which seem to be sufficiently compact and homogeneous, are largely composed of grains of feldspar, which readily decomposes, and this leads to the disintegration of the stone. On the other hand, a large part of the material produced from the quarry mentioned, and from others which supply the markets of the country, is handsome, strong and durable. The extensive use made of this stone during the last two hundred years has served to bring out fully both its excellences and its defects; and while it has enjoyed a popularity that has caused it to be used in our cities to such a degree as to give a sombre monotony of tone to the architecture of many of our finest streets, a sufficient number of instances where the stone has flaked and softened may be seen in every locality where it is used to prove the necessity of careful discrimination in its selection.

A dark, purplish brown sandstone, from Hummelstown Dauphin County, Pennsylvania, was shown by H. F. Martin and Struthers & Sons. This is a fine-grained and apparently strong and good stone, of which the tint is rather sombre, but it may be used with good effect relieved by lighter trimmings. It is from the Palæozoic rocks, and is probably of Lower Carboniferous age.

A purplish-red, very fine-grained, and compact sandstone, from Aquia Creek, Virginia, was contained in the collective exhibit of Struthers & Sons, of Philadelphia. It is apparently the same stone as that of which the Smithsonian Institution is constructed, and probably comes from the Triassic beds. It is redder, finer grained, stronger and more homogeneous than the brownstone of New Jersey and Connecticut.

Ohio Freestones.

The most varied and extensive display of building-stones in the Exhibition was that from Ohio, made partly by the Commissioners from that State, and in part by private individuals. The collective exhibit of the Commissioners was principally embodied in the Ohio State Building, which was constructed of stone furnished by quarrymen and dealers in various parts of the State. This afforded an excellent exhibition of the quality of the material used, as they were here directly applied to the purposes which they are intended to serve; and while the style of architecture adopted did not fully bring out the good qualities of all the varieties of stone shown, the test which this method of display afforded was on the whole highly satisfactory.

The Ohio building-stone formed three groups, in each of which there were several exhibits:

1. Limestone of the Niagara Group.

These constitute what are known in market as the Dayton and Springfield stones. Of these, the first was shown in the exhibits of Marcus Bosler and William Huffman, of Dayton, and B. C. Statler, of Piqua; the second by those of George Sinz, W. S. Thompson, and A. O. Hoffman, of Springfield. Both these are handsome building-stones, largely used in South-western Ohio, and exported thence to several of the Western States. The Dayton stone is of a pale dove colour, the Springfield stone lighter. Both are strong, fine-grained, and homogeneous, and work well under the chisel.

2. Limestones of the Devonian System.

These came from the quarries of Mr. Clark, at Charloe, and Dr. P. H. Clemons, at Marblehead. Both are situated in the Carboniferous limestone. The stone from Charloe is nearly white in colour, and has the appearance, when worked, of white marble. That from Marblehead is pale cream colour; both are handsome, strong, and excellent building-stones.

3. Sandstones of the Waverly Group.

The Lower Carboniferous, or Waverly series, furnish by far the largest amount of building-stone used in Ohio. The quarries are located chiefly near the northern and southern margins of the State, and they furnish an annual product which sells for more than a million dollars.

In Northern Ohio, the most important quarries are located at Amherst, Berea, Independence, and East Cleveland, all in the same stratum,—the Berea grit,—which, however, varies considerably in colour and grain. The Amherst stone was shown by a large number of exhibitors, whose contributions formed the greater part of the State Building, and of the collection of Ohio building-stones in the Mineral Annex.

The Amherst Stone is a light-drab, rather fine-grained, homogeneous sandstone, composed almost entirely of silica, having a strength of from 7,000 to 8,000 pounds to the square inch, and working with great ease and accuracy under the chisel. Its colour is pleasing and unchangeable, and it is justly esteemed as one of the handsomest and best building-stones in the country. The exhibitors of Amherst stone were The Amherst Stone Company, L. Halderman & Son, The Wilson & Hughes Stone Company, The Clough Stone Company, The Ohio Stone Company, and Worthington & Sons.

The Berea Stone is light-bluish-gray in colour, and somewhat coarser than the Amherst. It is generally sound and strong, but some of the layers contain iron sulphide, and are liable to stain and exfoliate. When well-selected, it is, however, a durable stone, and is highly esteemed for heavy masonry. It is also adapted to finer work. The State coat of arms, inserted in the gable of the Ohio Building, and carved by W. G. McNally, of Cleveland, was wrought from the Berea stone. The exhibitors of this stone were The Berea Stone Company and J. McDermitt & Co. The Black River Stone

Company contributed one course and a window to the Ohio Building, of a stone very similar to the Amherst in colour and texture. This was taken from near Elyria, Lorain County. The stone from the Independence quarries was furnished by J. H. Hurst, John Wagner, and the Wilson & Hughes Stone Company, of Cleveland. This stone resembles the Amherst in colour, but is a little coarser in texture. Like that from Berea and Amherst, it is extensively used for grind-stones.

The Peninsula Stone was sent by the Peninsula Stone Company, and the Euclid Stone by O. D. Ford, of Cleveland. These quarries are situated, the first twenty miles north, the second six miles east, of Cleveland. Both are opened in the Berea grit, and the stone they furnish has the same general character with those already described, but is somewhat coarser. In colour the Peninsula stone is light gray, the Euclid light yellow.

The stone taken from the Berea grit at the various quarries in Northern Ohio is the basis of a large and growing industry. It is exported to most of the Northern cities, both east and west. In New York it is known as the Ohio stone, and is becoming a favourite material for construction. The price at the quarries varies from twenty to fifty cents. per cubic foot, and the annual production has the value of about half a million dollars.

The Waverly Stone, of Southern Ohio, is quarried chiefly at Waverly, Pike County, and at Buena Vista, Scioto County; the former located in the lower portion of the Waverly series, the latter in the upper. The stone from this region is finer-grained and less silicious than that from Northern Ohio, and has generally a more decided bluish tint when freshly quarried, but becomes lighter and more yellowish on exposure. This is a favourite building-stone in Cincinnati, and forms the basis of a large export trade to the Western States. It is also more sparingly shipped to Philadelphia and New York. Though some varieties of this stone are liable to stain and exfoliate from the oxidation of the contained iron, as a general rule it is an excellent and very handsome stone, taking rank with the best and handsomest of the freestones of the country.

The Buena Vista Stone immediately overlies a bituminous shale, and has received from this an impregnation of petroleum, which the sun's heat sometimes brings to the surface in oily or black stains.

The exhibitor of the Waverly stone was M. F. Rickey, of Waverly; and of the Buena Vista stone, M. & J. H. Finnegan, of Cincinnati. J. Dougherty, of Newark, Ohio, exhibited blocks of fine brown and dove-coloured Waverly sandstone, which were handsome, but rather tender. The former is much used at Columbus, and is highly esteemed.

In the State collection was a block of banded and mottled red, fine-grained stone from the base of the Waverly formation, at Cynthiana, Pike County, which is striking and peculiar in appearance. It could probably be used with excellent effect in architectural decoration.

A variegated sandstone, of which the colours are red, yellow, and black, was shown by Z. S. Stocking, of Mansfield. This is a tender and rather coarse-grained stone, very striking in appearance. Though readily yielding to mechanical violence, it will not decompose by exposure, and for some architectural purposes can probably be used with good effect. This also is from the Waverly group.

The Conglomerate of Ohio, though supplying much building-stone for local use, is generally too coarse and tender to be highly esteemed.

Specimens of brown and purple sandstone from Cuyahoga Falls and Akron, in Summit County, contained in the State collection, deserve a passing notice. Of these, the first resembles in appearance the darker varieties of the "brownstone" of New Jersey and Connecticut, but it is much stronger and more durable. The second is a fine even-grained sandstone, containing much iron in the condition of anhydrous peroxide, and is one of the handsomest building-stones in the country. It is of a dark, purplish-brown colour, and has been used with excellent effect in association with Amherst stone in some of the finest residences of Cleveland.

The Coal-Measure sandstones, though strong and durable, are generally rather coarse-grained, and are rarely attractive in colour. To this rule there are, however, some marked exceptions, and in the exhibits of Ohio and West Virginia were many blocks of very beautiful and excellent stone taken from

the beds associated with the seams of coal. In the Ohio exhibit a handsome show of Coal-Measure sandstones was made by Messrs. Warthorst & Co., of Massillon, Stark County; by Maurer & Haid, Homer Hamilton, Byers & McIlhenny, Caldwell & Tod, and R. N. Montgomery, of Youngstown; and C. B. Wells, of Marietta.

The Massillon and Youngstown Stones are strong, homogeneous, and indestructible, but rather coarse in texture; they are drab, pink, and white. The first two of these colours are sometimes handsomely blended in the same block, and where shown in different blocks they give a variety which is generally admired to the plain walls of structures.

The Marietta Stone is a dark, greenish-gray sandstone, fine-grained, and uniform in colour and texture. All these sandstones, like those from the Berea grit, are used for grindstones.

A white sandstone much used for furnace hearths, but also a very handsome building material, was shown by Rhodes & Card, in the collective exhibit of the Tuscarawas Iron Company. It is quarried in Franklin Township, Tuscarawas County. A similar and more purely white sandstone is found in Perry County.

West Virginia Freestones.

In the collective exhibit of building-stones made by the West Virginia State Board, there was a large number of blocks of sandstone from the Coal-Measures, some of which were of excellent quality, and deserve special mention, viz.:

1. A greenish-gray sandstone from Weston, Lewis County, used in the construction of the new Insane Asylum at Weston. This is fine-grained, apparently homogeneous, and strong, and buildings made of it are said to be very handsome. The exhibitor was Dr. T. B. Camden.

2. Blocks of sandstone, apparently of excellent quality, sent by W. S. Willey, from Morgantown; the darker variety represents the stone used in the lock recently constructed on the Monongahela River; the lighter is that of which the dam at this lock is built, and both have been highly commended by the United States engineers in charge of the work.

3. Two handsome varieties of stone shown by Cecil Clay and R. L. Kestor, of Ronceverte Depôt. Of these, the first is a gray, strong, homogeneous stone, used in building the piers of the railroad bridge over the Greenbrier River; the other, a reddish-brown sandstone from the same locality, much used for building.

4. A handsome, fine-grained, brownish-drab sandstone, from the Coal-Measures on King's Creek, Hancock County, exhibited by the proprietors of the quarry, Messrs. J. & D. Hudson. It resembles the chocolate variety of the Waverly stone, quarried near Newark, Ohio, but seems to be harder.

5. A light-gray, rather fine-grained stone, resembling the gray Amherst, forwarded by Albert Laidley, of Barbersville, Cabell County.

6. A coarse drab sandstone from Grape Island, Pleasants County, said to form a massive ledge forty feet in thickness, exhibited by B. W. Browse.

7. A coarse, pale-red or pinkish sandstone from the mouth of Gauley River, sent by J. H. Miller, junr., of Gauley Bridge. This is not a handsome stone, but strong, and well adapted to heavy work.

8. Very light-gray, coarse, but strong and serviceable sandstone, shown by the Bogg's Run Mining Company, Wheeling.

9. A medium-grained stone, light gray, with darker clouds and veins; a good and handsome stone, from Fetterman, Taylor County, sent by A. Armstrong, Pruyntown.

10. J. & M. Waddell exhibited a fine-grained argillaceous sandstone of a brownish dove-colour, which looks well, but, from the quantity of alumina and mica it contains, is liable to weather.

Kentucky Freestones.

In the collective exhibit of the Geological Survey of Kentucky were many specimens of building-stone, most of which were limestones. Excellent

sandstones exist in several parts of the State, especially in the Coal-Measures of both the eastern and western basins; but only one of these was fairly represented in the Exhibition. This was a light-brown, fine-grained, homogeneous sandstone from the Coal-Measures of Hawesville. It is probably the same stone as that quarried on the opposite side of the river at Cannelton, which lies in heavy courses, is quarried with great facility in blocks of any desired dimensions, and has been proved to be an excellent stone.

The limestones of the central part of the State, from their proximity to the centres of population, the ease with which they are worked, and their good qualities as building-stones, have come into extensive use, and furnished many samples for the Exhibition. Of these a few of the most deserving will be mentioned, viz.:

1. The Kentucky Marble, taken from *Grunes & Harris' quarries, near Clay's Ferry, Fayette County.*

This is a magnesian limestone of Lower Silurian age, and is the material used for the construction of Henry Clay's monument in the Lexington cemetery. It is a yellowish cream-coloured limestone, more or less specked and clouded with darker spots. It is a handsome and serviceable building-stone, but scarcely deserves the name of marble, nor is it adapted to decorative purposes.

2. Bluish-Gray Mottled Limestone, from the *Lower Silurian Rocks at Benson Creek.*

A homogeneous and handsome building material.

3. Oölitic Limestone, from the quarry of *Belknap & Co., Bowling Green, Warren County.*

This is a nearly white homogeneous limestone of Lower Carboniferous age, and a typical specimen of the white or oölitic limestone so largely used for building in Kentucky and Indiana. From its granular texture it works under the chisel as easily and accurately as sandstone, and is, on the whole, a very handsome and useful stone. When wrought it has the appearance of a very light-coloured granite, and in most circumstances is a more desirable building-material, since it may be worked with so much greater facility. It will not, however, receive a high polish, and in cities where soft coal is used, is liable, like all limestones, to be corroded by the evolved sulphuric acid. Specimens of the same stone, but less uniform in colour and texture, were sent to the Exhibition from Hopkinsville, Princeton, and some other localities.

4. A Dove-Coloured Limestone, from *Glasgow Junction, Barren County.*

This is also from the Lower Carboniferous limstone, and is associated with the Kentucky lithographic stone. It is a handsome and apparently a good building-material.

Indiana Freestones.

A fine display of building-stones was made at the Indiana State Building, consisting chiefly of large blocks of oölitic limestone from different localities. The principal exhibits were made by Emanuel Link, of Salem, Washington County; Norris & Cummings, and J. D. Whitted, Bedford, Lawrence County; and John Mathews & Son, and Perry Brothers, Elletsville, Monroe County.

The collective exhibit of the Indiana Geological Survey, shown in the Mineral Annex, also contained a large number of blocks of building-stone, several of which seemed to be of excellent quality. Among these the oölitic limestones of Harrison and Hamilton Counties deserve special notice.

Illinois Freestones.

The building material of Illinois was very inadequately represented at the Philadelphia Exhibition. There were, however, a few specimens of the freestone from this State which may be mentioned, such as—

1. The Athens Marble, from *Joliet.*

This is the bluish-drab magnesium limestone of Niagara age, so well known and extensively used in Chicago. Some varieties have much the appearance of the Caen stone, but it is more compact and strong. It is sawed with facility, but under the chisel works with less ease than the oölitic limestones. It is, on the whole, one of the best calcareous freestones of the Mississippi Valley.

2. Dark-Red Sandstone, from *Carbondale.*

A homogeneous, moderately-fine, handsome, and good stone.

3. Light-Green Sandstone, from *Calhoun County.*

Handsome, and apparently of good quality.

4. Light-Drab Sandstone, from *Carbondale.*

The last three are from the Carboniferous formation, and form part of the collective exhibit of the Illinois Industrial University.

Missouri Freestones.

The granite of Missouri has already been referred to. In addition to this there were one variety of marble, one of limestone, and two of sandstone shown from this State; the former of these will be briefly described in another place. The limestone is that quarried by the Central Marble Company, at Canton. This is a dark drab or yellowish-gray stone, with very fine and uniform grain, quite handsome to the eye, homogeneous, and strong. It closely resembles the Athens marble, and takes rank with it as a building material. The sandstones from Missouri were—

1. A Light-Coloured rather Coarse Stone, from the *Lower Carboniferous at Nuremburg, Johnson County.*

Apparently a good, serviceable stone, but of no great beauty.

2. A very Fine-Grained Light Yellowish-Drab Sandstone, from the quarries of *Mr. E. T. Cromwell, at St. Genevieve.*

This was one of the handsomest building stones shown in the Exhibition, having the tint of the Caen stone, and apparently homogeneous in colour and texture. It is of medium strength (4,800 lbs. to the square inch), but works under the chisel with great ease and accuracy, and, composed as it is of nearly pure silica, will suffer little or no change by exposure. It resembles in grain and colour some of the Waverly sandstones of Ohio, but is of a lighter and brighter tint than those generally are, and, if it can be produced in quantities like the sample, must be a very valuable stone.

Kansas Freestones.

In the Kansas and Colorado State Building the splendid exhibit of the staple products of Kansas contained numerous specimens of her building stones. These were, however, generally small, and while several seemed to be fairly good only one calls for special notice. This is a very light-yellow

porous limestone, which belongs to the Upper Coal-Measures, and is found in a large number of localities through the central part of the State. The specimen examined was from Junction City. This stone is not remarkable for beauty, although it looks well when laid up in walls; but its excellence consists in the facility with which it is worked. When taken from the quarry it is so soft that it may be sawed like wood, but it subsequently hardens, and will doubtless prove sufficiently durable. Both in colour and consistence it resembles the *Calcaire Grossier*, the common building stone of Paris, and may be used in the same way; that is, a wall may be built of it in the rough, and planed to a perfect surface or ornamented in place.

Colorado Freestones.

From Colorado three handsome blocks of sandstone were sent by John Evans, of Morrison, Jefferson County. These were about three feet in length by one and a half wide and eight inches thick; one gray, the other two of red-banded stone. Both kinds are fine-grained, handsome, and apparently good.

Michigan Freestones.

From Michigan two exhibits only of building stone were made. Both these were of the purple sandstone which forms so much of the southern shore of Lake Superior; one sent by the Burt Freestone Company, of Marquette, the other by the L'Anse Brownstone Quarry Company, of L'Anse. Of these the best known in the Western States is the Marquette, or Bass Island stone, so named from the principal localities which supply it. This stone varies considerably in colour and grain; it is generally purplish or brownish-red, of a rich, agreeable tint. Some varieties, like the specimens sent from Marquette, are quite fine-grained and strong, while the Bass Island stone is rather coarse and tender; both, however, are composed of silica and iron, with perhaps a little manganese, and will be very resistant to weathering, and where not exposed to mechanical violence even the softest will prove durable. Lake Superior sandstone has been extensively used in Chicago, Milwaukee, and other Western cities, and its many good qualities have been already demonstrated.

III. Marbles.

In common language any hard, calcareous rock which will take a polish is called marble. But strictly speaking, only those limestones which have been subject to metamorphic action can be properly designated by this term. For example, the so-called black marbles of Glenn's Falls, New York, of the Wyoming Valley, Pennsylvania, and of Coshocton County, Ohio, are simply limestones coloured black by carbonaceous matter; while the "Athens Marble" of Northern Illinois, the "Marble" of Canton, Missouri, &c., are drab limestones. All these are compact and fine-grained, and take a fairly good polish, but are much less crystalline and hard, and receive a less brilliant polish than the true marbles, which are limestones that have shared the metamorphism that converts shales into slates, sandstones into quartzites, &c. Hence true marbles are only found in regions underlaid by metamorphic or changed rocks, where they are associated with granites, micacious and talcose slates, argillite, &c. Such regions are usually mountainous, and all mountain chains are composed of metamorphic rocks. With these facts in mind it is easy to understand why, in our own country, true marbles are confined to the Canadian Highlands, New England, the Alleghany belt, and the great mountain chains of the Far West; also, that in the Old World the marble quarries are located in disturbed and generally in mountainous districts. It must not be inferred, however, from these facts that the marbles are necessarily very ancient rocks, for the causes which have operated to elevate mountain chains and metamorphose the rocks which form them have acted in all geological ages, and some of the most beautiful marbles known are from comparatively recent formations, such

as the Carrara statuary marble, which is a metamorphic limestone of Jurassic age.

Marbles, in commerce, are divided into two groups, the white and the coloured. In the first category are placed not only the pure white statuary marble, but those which are chiefly white, though specked, clouded or veined with darker colours. The coloured marbles comprise those that are gray, blue, black, green, red, and yellow, or mottled by various mixtures of these colours with each other or with white. Marbles also vary much in their chemical composition, their texture, and their structure, some being nearly pure carbonate of lime, while others—and among these some of the most highly esteemed—contain large quantities of magnesia. In texture they vary from those in which the paste is scarcely granular to such as are very coarsely crystalline. This latter characteristic does not prevent their receiving a high polish, though the finer-grained marbles excel in this particular. In structure they may be homogeneous, though coarse, or veined and brecciated as though composed of a mixture of very different materials; and further, they may be pure or impure, that is may contain silicious masses technically known as quartz and flint, or "curdle," which is generally tremolite; they may be sound or unsound,—by which is meant solid and compact,—or checked and fissured by cracks or veins; and finally, they may be strong or weak, durable or perishable. The quality of first importance in a marble is beauty, for it is chiefly a stone of ornament, and their varied and attractive colours and brilliant polish constitute the shining qualities of the most esteemed marbles; but the uses of marble are various, and are often such as to require both strength and durability.

The rarest and most highly-prized of all the marbles in common use is the pure white statuary, like the best Carrara and Pentelic marbles. Of this the best grades are worth as much as twenty dollars a cubic foot in the chief markets of the world. Such marble is used almost exclusively for statuary, and the supply of that which is pure in colour and faultless in texture is always inadequate to the demand.

The uses to which the "white marbles" are devoted are quite varied, and admit of a diversity of quality. The finest "white stock" including some statuary, is used for mantels and furniture; the second grade, typified by the "veined Italian" (which is not veined at all, but only slightly mottled or clouded), for the same purposes and for monuments; while "monumental stock," white, mottled with dark blue or gray, generally also banded or clouded, is chiefly employed for sepulchral monuments, while the coarser white, pure, or clouded, forms the material of which are composed the most beautiful, if not the grandest structures raised by the hand of man.

As has already been stated, the display of marbles at Philadelphia was very extensive and varied. In fact, it included nearly all the varieties of marbles known, both ancient and modren.

American Marbles.

Much the largest quantity of marble shown in the Exhibition came from American localities, and the most impressive exhibits were from Rutland County, Vermont, which is the great centre of the marble-industry of the United States. The display of white marbles made by the West Rutland Marble Company, the Messrs. Ripley, Sheldon, & Slosson, the Sutherland Falls Marble Company, the Burlington manufacturing Company, &c., was really magnificent, and such as not only illustrated the excellence and variety of the material produced, but also the enterprise and public spirit of the exhibitors. The exhibits of coloured marbles made by the Columbia Marble Company of Vermont, and the East Tennessee and Knoxville Marble Companies, were equally creditable, and massive blocks, and wrought marble in various forms, the product of their quarries and workmanship, attracted much attention among the visitors to the Exhibition; while the smaller but much more varied exhibit of coloured marbles from Lake Champlain and Maryland were a surprise and a revelation to most, as few had any idea that such beautiful ornamental stones existed on this continent. Some of the exhibits thus generally referred to deserve more detailed description, and notes are given upon them below.

WHITE MARBLES.—All the American white marbles shown in the Exhibition were sent from Rutland County, Vermont. Here they are found in belts or layers of different thickness, which form part of the Eolian limestone series, lately proved to be of Lower Silurian age, and the equivalent of the Trenton group of New York. The whole Eolian series is more than two thousand feet in thickness, but the greater part of it consists of coarse gray silicious limestones of no value as building-material. With these there are interstratified beds of pure white, clouded, dove-coloured, and gray-mottled marbles which are quarried at West Rutland, Rutland Centre, Sutherland Falls, Pittsford, Brandon, and Middlebury; the marble quarries of Dorset, Manchester, and Danby are located farther south in the same general belt. The marble layers are generally inclined at a high angle, in some places standing nearly vertical, and varying in thickness from sixty feet at West Rutland to four hundred and fifty at Pittsford. The individual layers are from three to five feet in thickness, and differ much among themselves in colour and texture, the varieties of marble which they afford bearing different names. The West Rutland marble is the most brilliant white in the series, but is somewhat tender and absorbent, and hence is best fitted for use in situations where it is not exposed to the weather. From the West Rutland quarries comes the only American statuary marble yet known in the markets. This forms a layer of from three to five feet in thickness, of which the stone equals in beauty any other marble known. A fine display of this variety was made in the Exhibition by the West Rutland Marble Company, Ripley and Son, Sheldon & Slosson, and Gilson, Clement and Woodfin. Some of the marble obtained from the Goodale quarry, at Brandon, Vermont, is of statuary quality as regards texture and color, but occurs in layers so thin that large blocks cannot be obtained from them. Most of the so-called white marble of Vermont is more or less mottled with green or black, and ranks with the "veined Italian." Much of it is very handsome, as was shown by the series of slabs exhibited by the Rutland Marble Company, and Ripley & Son. Of these, the first consisted of eight, the other of nine, polished slabs, each two by four feet surface, including all the varieties taken from the West Rutland quarries, and designated as No. 1, No. 2, DARK BLUE, BEST No. 3, BROCADILLA, LIGHT No. 3, AVERAGE, MOTTLED BLUE, and DARK No. 3. The quality of the marble was further illustrated by a series of cubes one foot in diameter, and another of six-inch cubes, and large blocks, tiles, wrought marble, &c. All these varieties are extensively used for furniture, mantels, counters, and monuments, constituting the bases of the largest commerce and industry in our domestic marbles.

The marble of Sutherland Falls made a good display in the exhibit of the Sutherland Falls Marble Company. This is all mottled, but is a sound, strong, and good stone, chiefly used for monumental purposes, and highly esteemed throughout the country.

The Eureka quarries, located between Rutland and Sutherland Falls, also furnish some excellent light stock, and four handsome blocks of clouded marble were shown in the Exhibition by the Eureka Marble Company.

The marble of the Pittsford quarries was imperfectly represented by the exhibit, creditable though it was, of the Burlington Manufacturing Company. The marble deposits of this locality are without rival in the country as regards magnitude, and include many varieties of white, mottled, and blue marble, few of which have yet been brought into market. The larger blocks and slabs of the Pittsford marble were all of the light mottled varieties, but smaller specimens were shown consisting of pure white, fine-grained, statuary marble, coarser pure white, light blue or "dove," and dark clouded blue like the Columbian, all apparently of excellent quality. The marbles of Pittsford have an excellent reputation among dealers and manufacturers for strength and soundness, but the best varieties found there have only been recently discovered, and are as yet little known to the public. It is probable, however, that the demand for marble in this country will in the future be much more largely supplied from this source than it has heretofore been.

The marble of Brandon, Vermont, has long been in market, and has been justly esteemed for its fine grain and pure white colour. It has been, however, most used for tiling and other purposes where slabs could be employed, as the quarries did not furnish blocks of large size. Handsome clouded white marble

is, however, obtainable in Brandon in larger masses, and a block about two feet cube, polished and sculptured, was exhibited in the Government Building by the Richmond Marble Company, which rivalled in colour and grain any of the mottled white marble in the Exhibition.

White marble of remarkably fine quality, as regards color and texture, is found in several localities north of Brandon, as at Shelburne, Middlebury, &c.; but most of this is unsound, and the quarries which have been opened in this region have up to the present time not been successful. The marble here is more crystalline and translucent than that of Rutland County, and some of it resembles, while it fully equals, the famous Greek Pentelic marble.

Passing southward from Rutland, valuable deposits of light marbles are found at Danby, Dorset, and Manchester, each of these localities having furnished considerable marble to the markets of the country. It is noticeable, however, that the marble becomes coarser in going southward from the present centres of production, and no really first-class stone is found south of the Vermont line.

The Dorset marble was represented in the Exhibition by a creditable display made by Samuel F. Prince, of East Dorset. This consisted of two slabs of clouded marble, two by four feet, and two polished cubes, about one foot in diameter. This marble is apparently strong and sound, of good grain, but is somewhat dull in colour.

The quarries of Manchester supplied the marble for the fine block erected by Drexel & Morgan, at the corner of Wall and Broad Streets, New York City. The only specimens of it seen in the Exhibition were some included in the collective exhibit of Messrs. Struthers & Sons. This marble is intermediate in character, as it is in geographical position, between the Massachusetts and the Rutland County varieties. It is rather coarse-grained, and better adapted to constructive than ornamental work, but makes handsome monuments. In colour it is white, streaked or clouded with black or gray.

Architectural Marbles.—The marbles referred to in the preceding paragraphs are such as are chiefly used for statuary, furniture, interior decoration, and monumental purposes. It is true that some of them are frequently and advantageously employed for construction, and the marbles of Pittsford, Dorset, and Manchester have supplied the material from which some of the most beautiful blocks of buildings in the country have been constructed; still, they are mostly used for other purposes. There is also another group of white gray, or mottled and banded light marbles, which are of coarser grain, and, while unfitted for the finer uses specified, are admirably adapted to the construction of buildings, and are so much more frequently employed for this purpose than any other marbles that they may with propriety be classed as architectural marbles. In this category come the coarse-grained white marbles of Berkshire, Massachusetts, Canaan, Connecticut, and the still more coarsely crystalline dolomites which form so conspicuous an element in the Eozoic belt of rocks which underlie the surface east of the Hudson and north of the city of New York. These re-appear in the Alleghany belt, and are represented in Maryland by the white marble quarried at Ellicott's Mills and elsewhere.

The principal quarries which have supplied the architectural marbles are:

1. *Lee, Massachusetts.*—The marble from this locality has been, perhaps, more largely used in the construction of public buildings than any other in the United States, as the material for the extension of the Capitol at Washington and for the New City Hall of Philadelphia, as well as that for many smaller structures, was derived from this source. The Lee marble is for the most part of a uniform though not brilliant white colour, is coarser grained than the Vermont marbles, and yet finer than those of New York. It is a strong and durable stone, but contains a little iron, by the oxidation of which it becomes somewhat brown on exposure. It is doubtful whether its strength and durability are materially impaired by this, and the change of colour which it produces is by some architects regarded as an excellence rather than a defect.

2. *Stockbridge, Massachusetts.*—This marble was exhibited by Mr. Struthers, of Philadelphia. It is similar in character to that from Lee,—namely, is, for marble, coarse-grained, resembling coarse loaf-sugar. It is mostly white, but banded with dark stripes along the lines of deposition.

There are many other quarries in Berkshire county which have produced a large quantity of marble through many years, but which had no representation in the Exhibition,—as at North Adams, Great Barrington, New Ashfield, Lanesboro', Sheffield, etc. The old Capitol at Albany was constructed from the Lanesboro' marble; most of the stone used in building the City Hall of New York and a part of that in the State House in Boston was from Stockbridge; while the marble for the columns of Girard College, in Philadelphia, was obtained in Sheffield. The marbles of Stockbridge and Lee apparently lie in the same belt with those of Manchester, Dorset, Danby and Rutland, and belong to the Eolian limestone series. Those which follow are older, containing much more magnesia, and probably representing the dolomites of the Laurentian of Canada.

3. *Canaan, Connecticut.*—This is the marble used in the construction of the new State House at Hartford. It varies somewhat in colour and texture, some of it being very white and of fine grain, and well adapted to monumental purposes; the greater part, however, is bluish-white or mottled. This is harder to work, more durable, and best suited for building.

4. *Tuckahoe, New York.*—The quarries which furnish the Tuckahoe marble are located on one of the several belts of crystalline dolomite which traverse, with a north-northeast and south-southwest bearing, the country north of the city of New York. Of these, one reaches New York Island, crossing Harlem River at King's Bridge; another out-crops on the Sound near New Rochelle; others still strike the Hudson above New York, at Hastings, Dobb's Ferry, Sing Sing, &c. Several of these furnish good marble for building-stone,—gray, blue, or white,—but none that is fine for decorative purposes. The best marbles yet obtained from this series of deposits are those of Tuckahoe and Pleasantville.

The Tuckahoe marble is pure white in colour, and much coarser in texture than any of those hitherto noticed. It is somewhat irregular in quality, but the better grades are highly esteemed for architectural purposes, and have been used in some of the finest buildings in the city of New York. The stone for the residence of Mr. A. T. Stewart, at the Corner of Thirty-fourth Street and Fifth Avenue, as well as a portion of that which has been used in the Cathedral, came from these quarries. By exposure in the impure atmosphere of the city, its colour changes to a light gray. This is apparently due to coarseness of texture, which gives roughness to the surface, and causes the smoke and dust to adhere to it more closely than they would to a finer stone.

5. *Snowflake Marble, Pleasantville, New York.*—The dolomite belt in which the Pleasantville Marble quarries are situated is one of the broadest known, being more than half a mile in width. It consists chiefly of beds of impure dolomite white or banded, which contain too much silicious matter to be available for building or ornamental purposes, with some layers, often of considerable thickness, of pure white marble, in part similar to that of Tuckahoe, and partly still more coarsely crystallized. These beds are more or less interstratified with layers of granite and gneiss, the whole series standing nearly on edge. Among the marble layers in this locality, the most conspicuous and valuable is that which is worked by the Pleasantville Land Company, and which furnishes the "Snowflake Marble." This belt is about four hundred feet wide, standing vertical, and consists throughout of pure white dolomite, almost without cloud or stain, and with no foreign matter. This stone has been subjected to a series of tests by General Q. A. Gilmore, U. S. A., and has been shown to offer a resistance to crushing force of from 18,000 to 24,000 pounds to the square inch,—a strength not equalled by any other marble or limestone yet experimented upon. The snowflake marble has been quite extensively used in the city of New York. It supplied most of the material for St. Patrick's Cathedral, and for the bank building at the intersection of Sixth Avenue and Broadway.

Coloured Marbles.—The so-called white marbles have in all countries been much more largely used than those that are mottled, or of deeper and brighter colours, since they are better adapted to monumental and architectural purposes for which the chief demand for marble comes. The more purely decorative marbles are also more strictly articles of luxury, as they have been chiefly employed for the decoration of the temples and palaces of the Old

World, and the dwellings of the rich. Hence, in the earlier history of our country, before the population had accumulated wealth, and while yet great simplicity of manners prevailed, there was almost no demand for material of this kind. In later times, however, since the population of the United States has come to equal that of the great nationalities of Europe, and there has been a proportionate increase in the number of wealthy men, decorative art in all its departments has attracted more attention, and there has been a constantly-growing demand for pictures, statuary, and many other things which are the indices of a cultivated taste, at the same time that they are the fruit and expression of a luxurious civilization. Among other beautiful things the purely ornamental stones have come into quite general use, and the richly-coloured marbles have in various forms been introduced into our public and private buildings to such a degree that they have come to be the basis of a very important commerce and industry. Very naturally the market has hitherto been mainly supplied from the quarries and factories of the Old World, where during three thousand years the use of purely ornamental stones has been large and continuous, and the search for them so wide spread and incessant that the resources in this line of the whole Eastern continent have come to be pretty well known. At the same time the art of working and combining these materials has grown to be an almost distinct and independent avocation, and skilled labour, in this as in other industries, has been not only attainable everywhere, but so cheap as to defy competition. All these influences have given the European coloured marbles the possession of our markets, and it is only quite recently that any attention has been directed to our own deposits of this kind. Twenty years ago no valuable American coloured marbles were known; but since that time, and mainly within the last ten years, they have been sought and found in several States of the Union. In two or three localities they have been quite largely quarried, and a few varieties of coloured marbles produced on this continent are now recognised and even staple articles among marble-dealers and manufacturers. The subject is, however, still a new one among us, and we hardly know what our resources of this kind are. Yet enough has been learned to authorize the statement that the United States is as well furnished with beautiful coloured marbles as any other country in the world; and that the time is not far distant when the demand for such ornamental stones will be chiefly supplied from our own quarries. That the most beautiful foreign marbles will continue to be largely imported is altogether probable, as their precise counterparts will certainly not be found in this country; and for certain purposes, and to gratify certain tastes, they will continue to be preferred and used.

The display of American coloured marbles at the Exhibition was, however, to all whose attention was drawn to the subject, a revelation; and, while many beautiful marbles doubtless yet remain to be discovered among the varied mineral resources of our country, and of those already known the actual character and practical value of but few have been determined, it is certain that we have abundant supplies of black, gray, and mottled marbles, which at least promise to rival in variety, beauty, and excellence the most highly-esteemed coloured marbles of the Old World.

Foreign Coloured Marbles.

Before describing the American coloured marbles shown in the Exhibition, it will perhaps be better to refer briefly to those from foreign countries, which were either sent directly from those countries or formed part of the exhibits of our own marble-dealers or manufacturers.

The coloured marbles forwarded by Belgium, Portugal, Spain, and Italy have already been referred to, but by far the fullest display of foreign marbles was made by American importers. Of these, the most complete series was shown by Messrs. A. L. Fauchere & Co., of New York; but interesting specimens were also shown by Fisher & Bird, of New York, Struthers & Sons, of Philadelphia, and others. Some forty varieties of European coloured marbles were contained in the series shown by Fauchere & Co,, and as these represent all the best-known varieties of imported marbles, they will be briefly noticed in order.

1. Formosa.—This is a beautiful stone, of which there are two varieties, the first dark red and greenish-brown mottled, the second light brown, veined with white and yellow; from Germany.

2. Bougard.—Of this also there are two kinds, one clouded with large but irregular figures of reddish-grey, red and white, traversed by viens of yellow; all the tints obscure. The other is more distinctly striped, the colours red, gray, yellow, and white, resembling the Egyptian alabaster; both very handsome; from Germany.

3. St. Remi.—The colour of this marble is dark red, veined and spotted with white. The tint is subdued and a little sombre; from Belgium.

4. Light Royale.—Of this the colour is pinkish-red mottled with white and dove; very delicate and handsome; from Belgium.

5. Sarrancolin.—This is one of the best-known and most admired of the foreign coloured marbles. Its colours are green, red, white, brown, and orange, in subangular patches, or it is mottled and veined in the same colours. It is the type of a group of mottled and brecciated marbles much esteemed for library and dining-room mantels, and for various kinds of interior decoration, where it is used in combination with other marbles of contrasting colour. It comes from the Pyrenees, and, like many other coloured marbles, is exported from Marseilles.

6. Campan.—The prevailing colour of this stone is a pale yellowish-green, mottled with white in a figure like "mackerel clouds," and more or less traversed by veins of white. It is a well-known and much-admired marble. A dark-green variety, containing much red, is called the *Campan Rouge;* from the Pyrenees, France.

7. Rose des Pyrénées.—This marble is finely mottled, pale and dark-rose red, flecked and veined with white. A variety of this, called the *Viel Brun*, is brecciated and mottled pale red, white, and dark brownish-red. Of this the tint is rather sombre; from Spain.

8. Rouge Jaspé.—This is light red, yellow, and white, and is blotched but not brecciated. A lighter variety is called the *Rose du Var*. This is pale yellowish white, divided into subangular areoles by pale-red veins; from the Pyrenees.

9. Vert Maurin.—This is a dark-green mottled marble, veined with light green and white; the figure is small, the colour brilliant; it takes a fine polish, and is the handsomest and most esteemed dark-green marble; from Grenoble, France.

10. Echaillon.—One of the Mont Cenis marbles, of which there are some half-dozen varieties, all fossiliferous limestones, varying in colour from nearly white, through pale red and gray to black. This one is a very light cream colour, somewhat variegated by inclosed shells. It is very delicate in tint, and handsome, but peculiar, and only adapted to special uses; from Grenoble, France.

11. Breche Herculaneum.—A handsome brecciated marble, variegated with dark and light brown, yellowish-red, and snow-white, in angular patches; from Belgium.

12. Breche Violette.—This is like the last in general character, but lighter, being brecciated with pinkish-white patches, divided by purple veins; from the Pyrenees.

13. Griotte des Pyrénées.—A dark-red mottled marble with small white spots, somewhat resembling, but less handsome than the next; from the Pyrenees.

14. Griotte de Caune.—This is the well-known French *Griotte*. Its prevailing colour is dark red, but this is relieved by streaks of dark brown, spots of light red, and veins of white. It is a very beautiful marble, takes a good polish, and is among the most esteemed of all foreign coloured marbles. It is quarried near Caune, in Southern France, and shipped from Marseilles, like the Campan and Sarrancolin. It formed the material of a very beautiful mantel exhibited by Fauchere & Co. This will be remembered by visitors as the dark red one at the bottom of the alcove, and that which ran up to form a frame for the mantel mirror.

15. Griotte Panaché.—A variety of the last, and comes from the same quarries. It is dark red, streaked with white.

16. Breche Imperial.—This is another of the "calico" marbles, resembling those before described, but more pronounced; its colour consists of large reddish-yellow, angular blotches, separated by reddish granular spaces, the effect being patchy and staring; from the Pyrenees.

17. Lumachelle.—In many localities in the world limestones are found which contain fossil shells that still retain some of their nacre. These, which are usually fragmentary, reflect from the polished surface of the stone the colours of the rainbow. In the finest varieties the marble seems to be set with opals, and constitutes a peculiarly beautiful stone, especially adapted for inlaid-work, and other kinds of elaborate ornamentation. The Lumachelle under consideration is a stone well known to American marble-workers. Its general colour is dark brown, and its contained shells are usually angular fragments. It is said to be brought from the Pyrenees.

18. St. Baumé.—This stone is pale yellow veined with red, and one of the most beautiful of all the coloured marbles. It is in common use, and is universally admired; from the south of France.

19. Isabelle.—A dark reddish-brown mottled marble, of which the general aspect is purplish-red, but the tint is sombre and obscure, and the stone is generally unsound; from the Pyrenees.

20. Brocatelle.—This is a very handsome marble, of which the colour is pink, blotched with light yellow, and streaked with pale yellowish-green, and with lines or blotches of crystallized calc-spar. The term Brocatelle signifies a coarse kind of brocade used for tapestry; and this name, slightly modified, is used in France, Italy, and Spain to indicate a mottled marble in which the figure is small, and the general complexion similar to that of some woven fabrics; from Southern France.

21. Rouge Antique, or Rosa Antiqua.—This also is a mere variety of Griotte. It is characterized by the prevalence of roundish spots of bright red upon a dark-red background; these light spots are produced by spiral shells; from Southern France.

22. St. Ann.—This marble is dark gray mottled with white; the general tone is sombre; from Belgium.

23. Bardiglio.—This is the gray marble so much used for counters, soda-fountains, &c. Its colour is produced by a mingling of grayish-white with streaks and clouds of black. It is a very sound and homogeneous stone, takes an excellent polish, and is a great favourite with marble-workers. The *Bleu Turquin* is a variety of Bardiglio, dove-coloured, streaked with white; from Italy.

24. Lisbon.—This was one of the first coloured marbles imported into this country, and has been, perhaps, as extensively used as any other. Its prevailing colour is pale red, traversed by thin dark veins, which inclose rounded spaces, giving it a coarsely mottled appearance. As in nearly all the veined marbles, the veins in the Lisbon are lines of weakness, and take an imperfect polish. It is, on the whole, however, a marble which deserves the good reputation it enjoys: from Portugal.

25. Levanto.—This is a marble but little used in this country. It is mottled and brecciated with patches of dark green, dark red, and white; complexion rather sombre; from Italy.

26. Sienna.—Reference has already been made to the Sienna marble in the preliminary review of the building and ornamental stones of foreign countries. It is one of the best-known of the imported coloured marbles, and is very much liked both by manufacturers and the public. Its prevailing colour is light yellow; this is, however, variegated by thin tortuous veins, which are somewhat darker. The stone receives a fine polish, and is unusually sound and strong for a veined marble. Some of the specimens of Sienna marble shown in the Italian department were of nearly uniform colour, and closely resembled the *Giallo Antico* of the Romans; from Italy.

27. Black and Gold.—This is the dark-veined marble so much in fashion a few years since for mantels. For this purpose it has pretty much gone out of use, but is coming again into demand for various ornamental purposes. It is a marble of excellent quality, and its dark background veined with yellow makes it a very striking and handsome stone. It is now

difficult to get, and the market is chiefly supplied from the old mantels; from Genoa, Italy.

28. Belgian Black.—This is the most beautiful and highly esteemed of all the modern black marbles. It comes from Golzine, Belgium. It is very homogeneous, hard, and brittle; hence it is difficult to work, but it takes a polish like an onyx. The black marble of Dinant, Belgium, was also shown in the Belgian department, but is much less uniform in quality.

29. Victoria.—A moderately handsome marble, of which the prevailing colour is light red. When carefully examined, this is seen to be produced by cloudy rolls of white and light and dark red. It is quarried near Cork, Ireland.

30. Vert d'Egypt.—A green or purplish brecciated marble, composed of pebbles of various kinds cemented with lime. This is probably identical with the famous *Brecceia di Verde*, so much used by the ancient Egyptians, Greeks, and Romans; from Egypt.

31. Genoa Green.—A dark and rather dull-green marble, of which the colour is given by small dark-green spaces, separated by lighter green veins. It takes a moderately good polish, but lacks homogeneousness, and is much less admired than the Alps Green or *Vert Maurin*.

32. Grande Antique.—This is a dark-blue, nearly black, marble, with thin white veins in the lines of bedding; from Belgium.

The large and varied exhibit of coloured marbles contained in the Spanish and Portuguese departments of the Exhibition have already been briefly referred to. From the number and beauty of the specimens contained in these collections, they deserve more detailed descriptions than have yet been given them; but, unfortunately, we lack information in regard to the exact localities where these marbles are produced, the nature and extent of the deposits, the magnitude of the industries and commerce based upon them, and the relative value of the different varieties as tested by actual trial. Hence any notes that can now be given upon them must necessarily be brief and vague.

Portuguese Marbles.

The marbles of Portugal have for a long time been an important article of export from that country, and one Portuguese marble, the Lisbon red, is well known in the markets of the United States, and has been already mentioned. The special exhibits of marble in the Portuguese department were as follows:

1. Viscount de Bessone.

Thirteen specimens of polished marble, dark and light, clouded and veined, from near Cintra. The specimens were small, but the marbles were handsome and apparently good. They are said to be extensively wrought and exported.

2. Antonio Moreiro Rota.

Sixteen square slabs of marble and breccia, the marbles from Cintra, and the breccia from Setubal, also a tablet of ornamental marble-work. This was a large exhibit, and the marbles handsome.

3. Bureau of Mines, *Lisbon*.

Six blocks of breccia, and fifteen specimens of white and coloured marbles; the white marbles from Extremoz, the deep blue from Borba.

4. The Extremoz Marble Company.

Six specimens of yellow and white marble of fine quality.

5. Joaquim Antonio dos Santos.

Twelve large slabs of polished marble from Cintra, Oporto, and Lisbon. These marbles were very handsome, and formed a large and beautiful exhibit. They are said to be exported to the value of $100,000 per annum.

6. Germar José dos Salles.

Twelve large slabs of white and coloured marble from Lisbon, Cintra, &c. This was a very fine exhibit, the marbles handsome and well furnished.

Spanish Marbles.

The principal exhibits of marble in the Spanish department were:

1. Ayuntamiento de Salas, *Oviedo.*

A series of handsome white, encrinal, and green marbles.

2. Comision Provincial of Burgos.

Twenty five-inch cubes of coloured marbles, a very beautiful series.

3. Francisco Dazas, *Macael.*

Three blocks of marble,—one pure white, but coarse; one white banded; and one gray.

4. José Maria Nuñez, *Cadiz.*

Twenty-four specimens of coloured marbles.

5. Ayuntamiento de Cabra, *Cordova.*

Ten specimens of polished coloured marbles.

The above exhibits embraced a large number of beautiful samples of marble, which, as they bore no special names, it would be impossible to identify, and therefore useless to describe. The number of exhibits of building and ornamental stones in the Spanish department was seventy-two. They consisted chiefly of marbles, but also included alabasters, serpentines, granites, and various other stones, all of which served to illustrate the richness of the country in materials of this kind, and the thoroughness with which their qualities had been investigated.

It will, perhaps, surprise the readers of this report to learn that after the exhibit of Canada, the collections of building and ornamental stones in the departments of Spain and Portugal were the most systematic and complete of any in the Exhibition. In Portugal, the Board of Public Works of each of the Provinces seems to have made an exhaustive examination of all its resources in the way of materials for construction, and these were represented by complete suites of the stones which had proved to be of value, in blocks of uniform size and similarly dressed. The provincial commissions of Spain had also taken pains to send full suites of their building-materials. Doubtless in other countries of Europe similar investigations and collections have been made, but they had no representation in the Exhibition.

The above list comprises nearly all the coloured marbles that are brought to this country from abroad, and the best-known varieties that are to be found in the present markets of Europe. A very much larger number of marbles was, however, contained in the Roman collection, to which reference has already been made. This, the result of many years of effort on the part of Sr. Raffael Jacobini, of Rome, includes among its hundred specimens

probably nearly all the marbles that were in use among the Phœnicians, Etruscans, Romans, Greeks, and Egyptians; for in ancient as in modern times, the older edifices were despoiled for the adornment of the new; and some of the most beautiful marble columns and pilasters of the Christian churches of the present Holy City have been made to serve in turn as ornaments to, first, Egyptian, second, Greek, and, third, Roman temples, before they reached their final, or at least their present, resting-places. No detailed descripiton has been given by Sr. Jacobini of the marbles in his collection. There were, however, some famous marbles in the collection which demand a few words of notice. Of these the statuary marbles of Greece and Rome first claim attention, and though the little it is possible to say of them here might, perhaps, more properly have been said in connexion with the remarks already made on white marbles, still, as they can be but incidentally alluded to, such notes as can be given upon them may not inappropriately find a place with those on the coloured marbles, with which they were associated at the Exhibition.

Ancient Marbles.

Of the ancient white marbles, the most famous were the Parian and Pentelic of Greece. The Parian Marble was obtained from the island of Paros, one of the Cyclades, and was, perhaps, the most highly esteemed of the white marbles known to the ancients. It is not pure white in colour, but is rather of a yellowish tint. In grain it is comparatively coarse, but it worked with great exactness and received the most perfect polish. This it retained even after long exposure; so that the masterpieces of the sculptor's art wrought from it—the Venus de Medici, &c.—have come down to us in a state of perfection that is largely due to the indestructible nature of the material of which they are composed.

The Pentelic Marble, which divided with Parian the favour of the Greek, is finer grained and whiter than the latter, but it is apparently less durable. As its name indicates, it was taken from the quarries on Mount Pentelicus, in the immediate vicinity of Athens.

Carrara Marble.—With the introduction of Greek art into Rome there was naturally an importation of the material in which this art was embodied in Greece, and the quantity of Greek marbles used in Rome, both for statuary and construction, seems to have been very large, especially during the earlier centuries of the Empire. It was not long, however, after the Italian peninsula had come under Roman sway, before the Italian marbles, now so well known, were discovered and brought into use. Among these the white marbles found on the shore of the Gulf of Spezia early attracted attention, and in the Augustan age the Carrara marble had nearly supplanted the Parian and Pentelic, and the enormous quantity of marble consumed in the decoration of the Imperial City was chiefly supplied from this source. The statuary marble of Carrara combines the good qualities of the two Greek varieties which have been mentioned, though both may be found exactly imitated among specimens of it. On the whole, it is thought by sculptors to combine in a greater degree than any other known statuary marble all the possible excellences of a material of this kind.

Among the famous coloured marbles contained in the Jacobini collection we may mention:

1. The Nero Antico.—This is a jet-black marble of fine and homogeneous grain, and of such closeness of texture that it receives the most brilliant polish. Its colour is also apparently unchangeable, doubtless in virtue of its hardness, since the softer black marbles—which are in fact unmetamorphosed black limestones—lose their colour to a degree on exposure, by the oxidation of the carbon which produces it, and they frequently become quite gray. The antique black marble is now eagerly sought as a ground for mosaics and for other purposes, but this demand is only supplied from the ruins, as the locality of the quarries which furnished it is at present unknown. From its resemblance to the Belgian black, it has been suggested that it might have been derived from the same source; but the comparative abundance of the *Nero Antico* at Rome, and the magnitude of some of the pieces which are still extant, almost preclude the acceptance of the theory.

2. The Rosso Antico, the ancient red marble.—Much of this is uniform in colour, and that a rather bright red: in some instances, however, it is darker, and more or less mottled. This seems to have been used by the Etruscans before the advent of the Romans, as beautiful and highly-wrought specimens of it were obtained by the writer on the sites of more than one of the Etruscan cities. The place from which the *Rosso Antico* was derived is not certainly known, though a recent writer claims to have discovered the ancient quarries near the Bay of Scutari, in Greece.

3. Giallo Antico, the ancient yellow marble.—This was perhaps the most admired of all the beautiful marbles used by the luxurious Romans. As its name implies, its prevailing colour is yellow, generally a light tint, somewhat similar to that of the Sienna marble, but more uniform and positive. Other varieties are bright yellow or orange, and it is sometimes variegated with dark lines. This marble is very fine in texture, and takes a beautiful polish. The quarries from which it was obtained are not now known, but it is suspected that they were situated in Africa.

4. The Cipolino.—This is a gray marble, much used by the Romans, and is the material which composes the columns of the temple of Jupiter Serapis at Baiæ; those which have been perforated by boring mollusks to half their height marking the former submergence of the site of the temple. It is composed of bands or irregular layers of white marble, mixed with others of talcose or steatitic material.

5. The Pavonazetta, or peacock marble.—Apparently several distinct varieties of marble are known in Rome by this name. In a collection of antique marbles made by the writer many years since in Italy, one of the most beautiful, found in the Forum at Rome, was coloured with white rounded spots on a red ground. This was called *Pavonazetta* by the Italian sculptors; but another, and perhaps the true *Pavonazetta*, is coloured with wavy bands of green, bluish-gray, and white, which form somewhat rounded and highly-coloured figures that bear an imperfect resemblance to those of the peacock's tail. Of this marble many beautiful examples are to be seen in the churches of Rome.

6. Oriental Alabaster.—A stalagmitic marble, though generally, but of course incorrectly, called an alabaster. Its prevailing colour is a yellowish-white, but it is frequently banded with darker shades of yellow and red. This seems to have been a highly-prized ornamental stone among the ancients, as many specimens of it are found in Egypt, Syria, Greece, and Rome. It was the favourite material for vases, urns, &c., and these are found in the oldest sepulchres, quite a number being contained in the interesting collections made by Colonel di Cesnola on the island of Cyprus, now in the Museum of Arts at New York City. Magnificent slabs and columns of this beautiful stone are to be seen in the churches of Rome, especially in that of San Paolo fuori le Mura. The quarries of the Oriental alabaster are in Egypt. They were for centuries lost sight of, but have been lately rediscovered, and are now worked.

American Coloured Marbles.

As has been mentioned, the coloured marbles of this country have only lately attracted attention, and few of those which have been discovered are as yet worked. Vermont and Tennessee have indeed supplied nearly all the coloured marbles, other than black, that have been taken from our own quarries.

Vermont Coloured Marbles.—In Vermont a jet-black marble of fairly good quality is found at Shoreham, and a variegated gray, not unlike the foreign Bardigho, at Plymouth. At Rutland, certain layers of the Eolian series are of a bluish-gray, banded with black, and these are quite largely worked at the Columbian quarries. The Columbian marble is of good texture, takes a fine polish, and is highly esteemed among marble-dealers and consumers. Most of the coloured marbles of Vermont are, however, found on the east shore of Lake Champlain, where they are contained in the basal portion of the Lower Silurian system. These are quarried at Mallett's Head,

near Burlington, on Isle La Motte, and at Swanton. The Mallett's Head marble is generally known under the name of Winooski. It is mottled red, white, and brown, a hard stone, and somewhat difficult to work, but takes a high polish, and is very strong and durable. There is considerable variety in the tint of the Winooski marble, produced by the relative preponderance of the colours mentioned, and the size of the figure; some slabs being coarsely mottled with white and brown, others chocolate and pale red, and others still light red, specked and mottled with white.

The display of Winooski marbles made by Hon. David Read at the Centennial Exhibition was very attractive and interesting. It consisted of ten blocks from the Mallett's Head quarries, illustrating all the different varieties found there, namely, 1, mottled with white in large patches divided by veins and spots of dark and light red, Marble Island; 2, light red, clouded with dark red and brown, Wakefield Hill; 3, light red, finely mottled in two shades, with specks of white, Marble Island; 4, chocolate and white mottled in large figure, Marble Hill, Colchester; 5, dark red, veined with white; 6, pale purple, spotted with chocolate and white; 7, pale pink, clouded with red; 8, purplish-red, specked with dark brown; 9, pale pink, mottled with veins and spots of spar; 10, pale purplish brown, mottled with elongated spots of white and light red, bordered with chocolate. The last six varieties came from Wakefield Hill.

Specimens of the Winooski marble have been taken to Italy by Hon. G. P. Marsh, and he reports that they were much admired for the beauty of colour, and the hardness and soundness of the stone; most of the variegated foreign marbles being deficient in the latter quality, and requiring to have their defects masked by cement.

The Isle La Motte marbles are dark gray and black; the latter is less deep in colour than the Glenn's Falls and Lycoming black marbles, but is harder and stronger. It is largely used for tiling, in combination with white marble or slate; for this purpose it has been in use for twenty-five years, proving itself to be an exceedingly durable and serviceable stone. The "fine gray" and "coarse gray" are valuable building-stones, having been extensively used in the construction of the locks in the Lachine Canal, the piers of the Victoria bridge, &c., but they have little beauty as marbles. A thin layer in the Fisk & Barney quarry is an encrinal limestone, of which the ground-work is bluish-gray, and the fossils—joints of crinoids, &c.—are pink and white, making a handsome marble, similar in general appearance to the encrinal limestone of Lockport, but brighter in colour, harder, and taking a better polish.

The Swanton marbles are generally similar to those of Mallett's Head, and are doubtless taken from the northward extension of the same belt. A very beautiful series of the Swanton and Isle La Motte marbles was shown in the Exhibition by Mr. George Barney, of Swanton. It consisted of a large number of slabs and cubes, representing the four varieties of Isle La Motte stone already mentioned, and five from the Swanton quarries. The latter included, first, the SWANTON DOVE, a pale-blue or dove-coloured marble flecked and grained with white; second, PLAIN RED, of a uniform reddish-brown colour; third, CHOCOLATE MOTTLED, of which the name gives a good idea, since the colour consists of irregular spots and figures of light or dark reddish-brown; fourth, RED AND WHITE LYONNAISE, of which the prevailing colour is a rich chocolate-brown, but the surface is veined and mottled with lesser areas of pure snow-white, the whole producing a very bright and pleasing tint, such indeed as makes it one of the handsomest coloured marbles known; fifth, GREEN LYONNAISE, of which the colour consists of relatively large patches of pale red and white separated by irregular bands of brownish-green. This variety is more striking than any of the series, and some of the specimens are very beautiful, yet, by a delicate taste, the brown and white Lyonnaise will be preferred. All the Swanton marbles have the excellencies and defects of those of Mallett's Head,—that is, they are hard, and somewhat difficult to work, but take a proportionately fine polish, which they retain longer than softer stones. The mistake is frequently made of using these mottled, veined, and brecciated marbles for tiling, but this sort of wear speedily betrays the difference in hardness of the several parts and destroys their beauty; hence

economy as well as good taste will be consulted by using for steps, thresholds, tiling, &c., the monochrome marbles only.

Tennessee Marbles.—East Tennessee is now the source of supply of two well-known coloured marbles. Of these, the Dougherty marble, usually known as the "Tennessee marble," has been more extensively used in the United States than any other coloured marble. This is a metamorphosed Lower Silurian limestone, found in the Cumberland Mountains, and quarried at Doughertyville by E. D. Dougherty. The prevailing tint of the Tennessee marble is chocolate mottled with pure white, and is very pleasing to the eye. It is also commended by marble-workers as being strong and sound, and it takes, for a variegated marble, a high and uniform polish. The excellences of this marble were well brought out by the magnificent display of huge blocks, columns, slabs, &c., made in the Main Building, at the entrance to the Mineral Annex. There is no doubt that this will continue to hold the high position it has hitherto occupied among American marbles.

The Knoxville Marble is quarried by the Knoxville Marble Company, in the vicinity of Knoxville, Tennessee. This is a highly crystalline, compact, and hard marble, which varies in tint from brown to pink, but is not mottled, the colour being distributed in sheets and belts, so that blocks of considerable size can be taken out, which are of nearly a uniform shade. Usually the colour is pinkish-brown, traversed by lines of blue. It is free from cracks and flaws, and takes a very uniform and brilliant polish.

New York Coloured Marbles.—*The Warwick.*—This is the most beautiful coloured marble yet worked in the United States. Its prevailing colour is carmine-red, mottled with darker and lighter shades, and veined with white. It is obtained from the town of Warwick, Orange County. But little of it has been taken out, and it is said that the quarry is exhausted. Of this, however, there is doubt, and probably further investigation will result in the discovery of a larger quantity than is yet known. It is to be hoped that efforts will be made to continue to supply an article so much coveted by our architects and marble-workers.

The Glenn's Falls Black.—This is a very dark phase of the Trenton limestone, quarried at Glenn's Falls. It has been little, if at all, metamorphosed, and is simply a hard limestone impregnated with carbonaceous matter, to which it owes its colour. It is less hard and black than the most esteemed black marbles, but serves an excellent purpose for tiling, and is sometimes used for mantels and other interior decorations. Like all the black limestones, it will be found to lose its colour and become gray by exposure to the weather.

The Lockport.—This comes from the encrinital layer of the Niagara group, and is a gray limestone thickly set with fossils, most of which are the joints of crinoids. Some of these are tinged with red, while others have a blue or opalescent shade, all of which give an agreeable variety to the colour of the stone. It is less hard than the true marbles, and as a consequence takes a less brilliant polish, and is more easily scratched. When properly wrought, however, it is quite handsome, and is considerably used for mantels and other purposes.

The Moriah or Minerva.—This is more correctly an ophiolite or verd-antique marble, being composed of dolomite mixed with serpentine. It is quarried at Thurman, Warren County, and at Moriah, Minerva, &c., Essex County, showing considerable variety of colour in these different localities. Much of it is uniformly mottled with small spots of yellowish-white and dark green; while other specimens contain a preponderance of one or the other element, are darker or lighter, and are mottled with larger or smaller spots.

Marbles of Pennsylvania.—Though among the most richly endowed of all the States with useful minerals, Pennsylvania is not well supplied with marbles. A belt of "white" marble—white veined and clouded with much black—passes through the eastern part of the State, and has been considerably worked near Philadelphia, in Montgomery County. Specimens of the marbles from this region were shown in the Exhibition by Messrs. Struthers & Sons, and they have been quite largely used for building purposes, and for monuments in this section of country; yet but little of this material is suitable for ornamental purposes, or would come into the category of coloured marbles.

Ebony Marble.—The most beautiful American black marble shown in the Exhibition was that exhibited by the Pennsylvania Marble Company, and brought from near Williamsport, Lycoming County. It is a jet-black stone, not quite equal to the Belgian Black in purity of colour and hardness, but it is very black and takes a brilliant polish. It contains a few specks of pyrites, and here and there a hair-line ring of white, marking the section of a fossil; but it works with great exactness, and seems to be an excellent, as it certainly is a handsome, stone.

Maryland Marbles.—Reference has already been made to the beautiful collection of coloured marbles shown in the Maryland State Building. As most of them have not yet been quarried to any considerable extent, or fairly tested in manufacture, it is impossible to justly estimate their value. The specimens shown in the Exhibition were, however, such as to encourage the belief that quite a number of the Maryland coloured marbles will prove to have sufficient beauty and soundness to make them an important addition to the ornamental stones hitherto used in this country, and we may confidently predict that some of them will take rank with the most highly-esteemed marbles of the Old World. The few notes taken at the Exhibition on this collection of marbles will give some idea of their general character. They are as follows:—

1. *Red marble*, from near Union Bridge, Frederick County. This is a dark reddish purple, clouded and handsome.
2. *Dark red marble*, veined with white, from Avondale, Carroll County. Of this, two varieties, light and dark, were shown, both of which are very beautiful.
3. *Calico marble*, mottled, dove, pale red, white, and green; very handsome.
4. *Mossy-veined marble*, from near Union Bridge, Frederick County; gray with black tortuous lines.
5. *Salmon-coloured marble*, flesh-colour, with red and white veins; handsome.
6. *Lavender-veined marble*, from near Liberty, Frederick County; a ground of neutral tint, with white veins; very handsome.
7. *Copper-veined marble*, from near Liberty; a light flesh-colour with green veins, possibly unsound.
8. *Undulate marble*, from Windsor, Carroll County; clouded, red or pink, and white; very handsome.
9. *Variegated marble*, Carroll County; red, veined with white, veins large; handsome; a variety of No. 2.
10. *Ruby marble*, a variety of Nos. 2 and 9, but clouded.
11. *Black marble*, from Frederick County; very dark, but not jet-black.

A few scattered exhibits of coloured marbles remain to be noticed.

In the Virginia State geological collection was shown a slab of mottled and veined rose-red and white marble, which came from Madison Run, Orange County, sent by W. C. Scott. This had evidently been taken from near the surface, and was unsound. Probably with deeper excavation more homogeneous stone would be procured, and if so it would be a very beautiful marble. It is known that there are extensive deposits of marble in Virginia, both white and coloured, but they have not yet been sufficiently worked to fairly test their quality, and no specimens of them were shown in the Exhibition.

In the Delaware State collection were specimens of coarse dolomitic marble, not unlike the Tuckahoe; and also specimens of serpentine, none of which call for special description.

In the New Jersey collection specimens of *Rose crystal* marble were shown, a stone which has already been introduced into market. It is a somewhat coarsely-crystallised dolomitic marble, of which the colours are pale red and yellowish white, mingled in irregular spots, which blend with each other without definite outline. This groundwork is thickly specked with points of black carbonaceous matter. The aspect of this stone is handsome, and it takes a good polish; but the coarse crystallisation gives it an appearance of unsoundness, and causes it to crumble on the edges and angles. The exhibit of this stone was made by Mr. W. H. B. Thomas.

The Potomac Marble.—The so-called Potomac marble is a calcareous breccia, found on the Potomac River, above Washington. It consists of round or subangular fragments of limestone, the spaces between being filled with a heterogeneous paste of sand and smaller stones, some of which are black and some red. The larger fragments are light gray, or nearly white, the smaller green, blue, black, pink, &c., the whole forming a peculiar and not unpleasant combination. Like most stones of similar character, this is generally unsound, and liable to crack. It was, however, formerly much used for internal decoration, and composes the columns in the rotunda of the old House of Representatives at Washington.

Snisun Marble.—This is the only ornamental stone from the Far West shown in the Exhibition. It is the well-known stalagmitic marble which was formerly sent in considerable quantities from California to the Eastern States, and of which the deposits are now said to be exhausted. It is composed of carbonate of lime, deposited in layers of different shades of yellow and brown. These form bosses and mammillary masses, which, cut across, develop concentric or sinuous bands of lighter and darker colour, which are sometimes very beautiful.

The Mexican Onyx Marble.—The most beautiful ornamental stone, exclusive of gems, shown in the Philadelphia Exhibition, was the so-called Mexican onyx. This is really a stalagmitic aragonite, similar in general character to the Snisun marble, and the Egyptian onyx marble, but much more beautiful than either. For a calcareous stone it is very hard, and takes a polish like an agate. Its colours are pale yellow and yellowish-green in bands, while the surface is stained and veined with green and red. With these attractive colours, all of which are delicate, the stone is translucent, and permits the light to strike through it so that it seems almost luminous. The finest specimens of Oriental alabaster are dull and unattractive when compared with this beautiful material; and it is to be earnestly hoped that it will be found in sufficient abundance to supply the very active demand it has excited. Most visitors to the Exhibition will remember the splendid mantel of Mexican onyx which formed part of the exhibit of Messrs. Fauchere & Co., of New York; and in that gave abundant proof of its adaptation to interior decoration. But this is not the only use to which it can be put, for columns, pilasters, vases, clocks, jewel-boxes, &c., are made from it, which are not excelled in beauty by those fashioned from any other material known. The Mexican onyx is quarried at Tecalli, in the State of Puebla. Fine displays of it were made by Gutierres, Julian, & Co., of the City of Mexico, and by Fauchere & Co., and Fisher and Bird, of New York.

To the list of American marbles should be added the clouded white and black monumental marble from Arnprior, Canada, sent by Mr. P. T. Somerville. This is a white marble, clouded and banded with black from graphite. It is not handsome, but sound and strong, and well adapted to monumental purposes.

A large number of specimens of white and coloured marbles and serpentines were contained in the collective exhibit of the Canadian department, for the most part contributed by the Geological Survey. These were chiefly from the eastern provinces, but some were from Vancouver Island and British Columbia. Very few of the deposits from which these specimens came have been worked, and the qualities of the marbles yet remain to be determined. It is apparent, however, that the Lower Silurian black and gray limestones of Vermont and New York, and the coloured marbles of the Winooski belt, crop out at various localities north of the Canadian line, and there is every reason to suppose that they will in the future supply the materials for an important industry, and will contribute largely to the wealth of more than one of the Canadian provinces.

IV. SERPENTINES.

Quite a number of serpentines and ophiolites were shown in the Exhibition, and some of them have considerable merit as ornamental stones. The coarse, green serpentine of Chester County, Pennsylvania, was exhibited in various forms by J. H. Brinton. This is a well-known building stone, quite largely

used in Philadelphia and elsewhere, and is the material of which the new University building is constructed. It almost immediately assumes the appearance of age, which comports well with certain kinds of architectural design, and with the purposes of certain structures. It is also used in combination with other materials—brick and stone—with good effect; so that it adds an important element to the resources of our architects. The colour is yellowish-green; it works with great facility, is fire-proof, and is probably durable.

A handsome, dark-green serpentine from Broad Creek, Maryland, was shown by E. M. Bye. This is more or less veined and mottled, takes a good polish, and is adapted to many kinds of interior decoration.

Another dark-green serpentine was exhibited by the Hoosack Quarry Company. The colour is deep and uniform, and the stone seems to be dense and homogeneous. It contains chrome iron and magnetite like that from Maryland. The specimen shown—a single small cube—was too small to fairly illustrate the qualities of the stone, but this, at least, was good.

A slab of verd-antique marble was exhibited by S. M. Stone, of Milford, Connecticut. As is generally known, stones of this character are composed of interlaced bands of serpentine and white marble; a combination which exists in most of the so-called green marbles that have been described. Usually the verd-antique marbles lose their polish and beauty when exposed to the action of the weather, but they have always been much admired for the decoration of public and private buildings when protected from exposure.

A small exhibit of verd-antique marble was made from Roxbury, Vermont, but hardly sufficient to determine either its character or value.

A block of beautiful yellow and green serpentine was sent from Newburyport, Massachusetts, by C. W. Kempton. This is of the variety known as *precious serpentine*, being translucent as though saturated with oil, and its colours bright and handsome. In the Old World this has been somewhat largely used for small articles of ornament, inlaid-work, &c. It is rarely found in masses of any considerable dimensions that are homogeneous.

The catalogue of serpentines shown in the Exhibition would not be complete without reference to the splendid slab of green serpentine sent by Juan Rubio Perez, of Granada, Spain,—shown in the Spanish department.

V. Slate.

The excellences of slate as a material for roofing are so marked that they are generally appreciated, and on account of its durability, its cleanliness, and its resistance to fire, it is preferred for this purpose to any other material. It also has its share of beauty, for slates are red, purple, green, and black, and these colours are frequently combined by the architect in such a way as to form tasteful patterns, and thus render the roof an ornamental as well as a useful part of the structure. Slate has also come into general use for tiling, beds of billiard-tables, black-boards, &c., and for mantels,—either marbleized or plain,—so that the consumption of this article is really enormous. Fortunately, beds of slate adapted to all purposes are found in almost every district where metamorphic rocks occur; and they are worked on a larger or smaller scale in a countless number of localities.

Among the foreign exhibits of slate in the Centennial Exhibition were contributions from far distant and widely-separated regions. Norway sent slate from Tromsoe,—the extreme northern point of Europe,—from the quarries of the Laxfiord Slate Company, and from Christiania; the latter the exhibit of Mostue & Co.

The slates of North Wales are of world-wide fame, and being of excellent quality, and the quarries so situated as to afford special facilities for ocean transportation, they have supplied roofs to every quarter of the globe. This great slate-industry was represented by the contributions of the Cromerthin Slate Company, of Port Madoc, and the Pen-yr-Orsedd Slate Company, of Carnarvon, North Wales.

In the Portuguese department, a large exhibit of slate—mantels, slabs, and roofing—was made by the Vallongo Slate and Quarry Company, of Oporto.

In the Italian department was an exhibit of slate from Baveno, made by Nicholas della Casa.

From Tasmania, the Australasian Slate Company sent slate from their quarries on Piper's River.

Finally, good slate for roofing and tiling, green and purple, and of good quality, were contained in the collective exhibit of Chili.

The American slate exhibits were more than twenty in number, exclusive of three from Canada. These were all, with one exception, from New England and the Alleghany belt, yet not one tenth of the quarries now worked in this region were represented. No slate was sent from points farther south than Virginia, while it is well known that in North Carolina and Georgia the slate belts are as well developed as farther north; and none from west of the Mississippi.

The slate exhibits in the Canadian department were made by, 1, the New Rockland Slate Quarry Company; 2, the Melbourne Slate Quarry Company; 3, the Rankin Hill Slate Quarry Company; and, 4, the Danville School Slate Company. Of these, the quarries of the first two are situated in the same belt of slate near Richmond. The slate is red, green, and purple, and is of excellent quality, smooth, homogeneous, and strong. The strength of the New Rockland slate was shown by a cube of granite weighing 72 pounds being sustained in the middle of a strip $\frac{3}{8}$ of an inch thick, 5 inches wide, and $2\frac{1}{2}$ feet long. The exhibit of this company contained roofing-slate of eight sizes, and planed slabs for billiard-tables, hearthstones, library shelves, &c.

The Rankin Hill slate is red and green; it is obtained from quarries near Actonvale, owned by Mr. John Rankin, of Montreal. The exhibit was small, but the quality was excellent.

The Danville slate is principally used for school-slates, and seems well adapted to this purpose. It is obtained at Gansonville, near Danville. This was well shown in the varied exhibit of the Danville Slate Company.

Slate was sent from Maine by the Maine Slate Company, of Skowhegan, by A. H. Merrille, of Williamsburg, and C. H. Chandler, of Brownsville. The slates exhibited by all these parties are dark, almost black in colour, hard, and durable.

The exhibit of the Maine Slate Company was large and comprehensive, including roofing slate, and slabs prepared for different purposes.

The slates of Vermont, so largely worked at Poultney, Castleton, and Fair Haven, were not represented in the Exhibition. There are some fifty quarries in this district, producing chiefly roofing slate, and that of excellent quality. The colours are generally purple and green, but red slate is also found there.

In Washington County, New York, is another seat of the slate-industry, there being some thirty or forty slate quarries in this region. These are located in the same geological formation (Silurian), and indeed in the same belt with those of Southwestern Vermont. The centres of production are Middle Granville, Jamesville, and Hampton. The Granville quarries are about a dozen in number, and, with the exception of one, are devoted to the production of roofing-slate. The predominant colours are red, purple, and green, generally pure, but sometimes mottled. The quality of the slates is excellent. They are fine grained with smooth surfaces, of good strength and permanent colour. The red slates from the Granville quarries are specially sought for, and are shipped to all parts of the United States, and even to foreign countries. Slates were sent to the Exhibition from this region by Richard L. Williams, the North Bend Slate Company, the Warren Slate Company, and Williams and Evans; the last two sent only green; the former, red, green, and purple slates.

Pennsylvania has among her varied mineral resources extensive deposits of slate. These are worked at various points, and it is estimated that not less than three hundred quarries are opened on her slate belt. The most important district is that about Slatington. Another slate district is on the southern

border of the State, extending into Maryland, and known as the Peach Bottom slate region. The slates from both these districts are of fine and firm texture, split with smooth surfaces, and the prevailing color is dark blue. Red slates are, however, found near Easton and elsewhere. The exhibitors of slate from Pennsylvania were the Lehigh Slate Company, and the Columbia Slate Company, of Slatington; the Allentown Slate Company, of Lynnport; the Chapman Slate Company, of Bethlehem; the Chester County Slate Company, the Peach Bottom Slate Mining Company; and D. W. Drenton, of Philadelphia. The exhibits made by the parties varied much in magnitude, and somewhat in excellence. That of the Lehigh Slate Company, which is one of the oldest and best-known slate Companies of the country, exhibited the product of their quarries in a great variety of forms; roofing slate, black-boards, school-slate, baths, mantels, &c., of excellent quality, and where wrought of good workmanship.

From the Buckingham quarries, Buckingham County, Virginia, a handsome exhibit of roofing-slate was sent by Edward Roberts & Co. In colour it is black, the texture fine, cleavage uniform with smooth surfaces, contains no pyrites, and is apparently strong and good.

From the West, slate came to the exhibition from one locality only. This was from the Huron Mountains, on the southern shore of Lake Superior, and the exhibit was made by the Huron Bay Slate Company. This slate is black in colour, with smooth cleavage surfaces, uniform in texture, and strong. The deposits of Slate in the Huron Mountains are said to be unequaled in extent, and to include coloured slates as well as black.

Slate well adapted to roofing and other purposes is known to exist in a great number of localities, and in unlimited quantity in the Rocky Mountain and Sierra Nevada belts. All these deposits, so far as known, remain unworked.

There were many fine exhibits of slate manufactured into mantels, generally marbleized, &c., which attracted much attention at the Exhibition. These were, however, examined and reported upon in another group, and I will only mention the exhibits of Wilson, Gilmore, & Co., of St. John's, New Brunswick; the Williams Marble and Slate Manufacturing Company; Hayes, Coulter & Co.; J. B. Kimes & Co.; and Wilson and Miller, of Philadelphia; and the Allentown Slate Manufacturing Company, of Allentown, Pennsylvania, as illustrating a new and important use to which this protean material is now being devoted.

VI. Flagging Stone.

The display of flagging stone in the Exhibition was quite small. In the foreign deparments there was no flagging or tiling worthy of mention, and the three exhibits from our own country were very far from doing justice to our resources in material of this kind. These exhibits were:

1. Mr. F. K. Field, of Baltimore, Maryland, showed a collection of specimens of blue sandstone for curbing, flagging, &c., which came from New York, Pennsylvania, Maryland, and Virginia, the New York Stone being the famous "bluestone" of the Hudson River. This was not well shown, as the specimens were too small. The other samples of flagging were of rather coarse material, more tender and inclined to flake than the Hudson River stone. This latter is one of the very best flagging stones in the world. It may be quarried in slabs of almost any desired thickness or dimensions, the different layers varying much in this respect. The natural surfaces of these strata are comparatively smooth, and form a good walk without dressing. The stone comes from the Hamilton group of the Devonian system, and forms a belt of outcrop extending from Kingston on the Hudson to Port Jervis on the Erie Railroad, and thence southward. It is a fine-grained sandstone, generally dark blue in colour, —whence its name,—and is very strong and durable. When ground or sawed it forms a very smooth surface, and yet one that always has a tooth or grain which holds the foot well, whether wet or dry. In this respect sandstones are much superior to granites and limestones, which become slippery and dangerous when wet. White marbles, which have a distinctly granular and crystalline structure, are not likely to wear smooth, and thus make very good flagging; but they are expensive, are liable to stain when in contact with the

earth, and wear away more rapidly than the more silicious stone. From its abundance throughout the belt of country where found, and the proximity of the quarries to water transportation, the bluestone is furnished at a low price in all the seaport cities; and supplying, as it does, excellent flagging and curbstones, it forms one of nature's gifts for which the inhabitants of these cities have reason to congratulate themselves.

2. Mr. T. H. King, of Trumansburg, New York, exhibited much of the finest samples of flagging stone shown at Philadelphia. These were slabs some twelve feet square and six inches thick, of blue sandstone, similar in appearance and quality to that found on the Hudson.

3. The Forest City Stone Company, of Cleveland, Ohio, sent some of their flagging to form the walk which led to the Ohio State Building. This is a fine-grained, rather argillaceous blue sandstone, which does not split naturally into plates, but saws with facility. When thus cut it supplies material for flagging that is only inferior to the finished bluestone, in that it is softer, wears somewhat faster, and may occasionally be found to flake.

A similar stone to the Cleveland flagging, though somewhat softer (and its precise geological equivalent, both being Waverly), is the Buena Vista stone, quarried at Portsmouth, Ohio, and now quite largely shipped to the cities of the North and East. This stone was abundantly shown in the Exhibition, though not as flagging, and has been noticed elsewhere. Like the Cleveland "bluestone," it is sometimes saturated with petroleum, derived from a bituminous shale which it overlies, and this, brought to the surface by the sun's heat, produces an ugly though temporary stain. When laid side by side with the Hudson River bluestone flagging, as it often is, the Buena Vista stone, with its sawed surfaces, is pleasanter to the tread than the bluestone, unless this too should have been rubbed smooth. It is, however, more tender, and wears away faster.

VII. Minor Ornamental Stones.

The gems shown in the Exhibition, when cut, came into the category of jewelry, and were examined by the Judges of Group XI.; when uncut, were classed as minerals, and thus were assigned to another Judge of Group I. There remain, however, a few ornamental stones, shown in the Exhibition, which deserve notice, and which are not likely to be reported upon by any one else. Upon these a few brief memoranda are appended below. They are:

1. Malachite.—The very beautiful exhibit of malachite in the Russian department attracted the attention of most visitors to the Exhibition. Naturally the greatest display of this material was made by the Russians, since nearly all the malachite that has been used for ornamental purposes has come from the Ural Mountains. At Nijni Tagilisk it has been found in enormous masses; one mentioned by Murchison "having an area on the surface of eighteen feet by nine, and extending to an unknown depth." Solid blocks of the finest quality, a cubic yard in dimensions, were obtained from this mass. It occurs in numberless other localities, but usually in small quantity, and rarely of sufficient solidity and beauty to serve for ornament. Malachite has, however, been recently found in abundance in the famous Burra-Burra Mine, near Adelaide, in Australia; and a splendid slab, somewhat irregular in form, but some six feet long by three feet wide, was shown in the Queensland exhibit at Philadelphia.

Malachite, as is generally known, is the green carbonate of copper. It is produced by the decomposition of the oxides of that metal, and is usually confined to the upper portions of the copper-bearing veins where the ore or native metal has been exposed to the action of atmospheric water charged with carbonic acid. The better qualities are concretionary or stalagmitic in structure, forming sheets or botryoidal masses, composed of successive layers, which vary in colour from light to very dark green. When cut across these layers, they form circles and convoluted bands of different shades, to which the beauty of the material is principally due.

The malachite shown in the Russian department was chiefly manufactured, and formed a veneering to numerous tables, vases, and other articles. There were, however, large masses, some of several hundred pounds in weight, com-

posed of the mineral in its natural state, and many of these were purchased, either to be sliced by the manufacturers of jewelry and other ornaments in this country or to be placed in cabinets and museums.

The Queensland malachite to which reference has been made, came from the Peak Downs Mine. It was much darker in colour than the Russian, but fully equalled it in beauty.

Malachite occurs in connection with all the deposits of copper in this country, but generally in small masses, sheets, or strings, and such as are rarely compact and homogeneous enough to have any value other than as an ore of copper.

2. Labradorite.—A considerable quantity of this iridescent feldspar was contained in the Russian exhibit, where it chiefly appeared as veneering for tables. All of it, however, was comparatively dull in colour, and very inferior to the magnificent specimens obtained from the special home of this mineral, Labrador. The colours of the American labradorite are sometimes really gorgeous, presenting a vivid play of reflections in every shade of blue, green, and yellow, such as have almost no rivals in nature for brilliancy.

3. Rhodonite.—This is a silicate of manganese, hitherto a somewhat rare mineral, and but recently used as a ornamental stone. Its colours are red or pink, streaked and spotted with black. When compact, it is very dense and tough, and takes a high polish. The Russian rhodonite comes from the Ural and Siberia. None has been found elsewhere, adapted to ornamental purposes. A variety containing zinc (Fowlerite) occurs at Stirling, New Jersey. Some of it closely resembles the Russian rhodonite, but it is less compact, and fades on exposure to light.

4. Lapis Lazuli.—This has been from the most ancient times highly valued as an ornamental stone, not only on account of its rarity, but of its peculiar and beautiful blue colour. It is a silicate of alumina, lime, and soda, with some sulphur and iron, is nearly as hard as quartz, and takes a fine polish. It is nowhere found in abundance, and that of the finest quality comes from Persia, China, and Siberia. That of the deepest colour is most highly esteemed, and choice specimens are worth $20 to $25 per ounce. It never occurs in large pieces,—the largest mass of fine lapis lazuli known being a solid globe thirteen inches in diameter, which is in one of the churches at Rome. In the Oriental countries it is wrought into cups, vases, handles of weapons, &c. Among the European nations the finest specimens are used for jewelry, while the less pure masses are sawed into veneers, which are used for inlaid work, to incrust panels, tables, vases, &c. All the larger articles shown in the Exhibition which seemed to be composed of solid lapis lazuli, were simply veneered. In former times this stone was ground up to make the pigment known as ultramarine, and the demand for this—which had not only an unequaled but imperishable blue colour—caused the stone to be much more costly than it now is, since an artificial pigment rivaling the true ultramarine in beauty has completely superseded it.

Many specimens of lapis lazuli show on the polished surface minute yellow metallic specks; these are iron pyrites, and they frequently add much to the beauty of the stone.

5. Jade.—Specimens of this stone were shown in various departments of the Exhibition, and always serving a purely ornamental purpose. Indeed, this has been the longest and most widely used by the human race of all ornamental stones. It varies in colour from white to the deepest green,—in most countries the darkest colours being most highly prized. In China, however, a light variety is preferred. It is a very hard and tough mineral, exceeding quartz in hardness, and receives a high polish. Among barbaric nations it has been used for ear-pendants, nose-jewels, amulets, idols, &c., and good examples of these were shown in the New Zealand department, where the hideous conceptions of South Sea Island superstition were embodied in jade of the finest quality. In the exhibits of the Chinese and Japanese there were numerous specimens of jade wrought with great skill into personal ornaments or grotesque figures. In the Russian department jade was also shown in the form of cups and shallow vessels.

There are perhaps several distinct minerals known under the name of jade. Two have been identified, nephrite and jadite; the former including the

darker varieties found in New Zealand and Mexico, the latter the pale green stone used for making ornaments in China. They seem, however, to shade into each other, perhaps by mixture.

6. Quartz.—Several varieties of quartz were seen in different departments of the Exhibition, forming objects of ornament; for example, in the Scotch exhibit was a great display of the *cairngorm*,—yellow or brown quartz,—and amethyst,—quartz coloured purple by manganese,—set in the peculiar silver jewelry so characteristic of this country. In the Chinese department were several remarkably fine specimens of spheres of rock-crystal which have been so frequently brought from the East, and have excited so much surprise from the accuracy with which they are wrought; and among the beautiful things shown in the Russian department, not the least attractive were the ornaments of various kinds wrought from limpid or smoky quartz.

Agates, onyx, sardonyx, and carnelian appeared among the ornamental stones in many departments of the Exhibition; but naturally the greatest display of articles wrought from these materials was in the German department, and in the exhibit of agate-work from Oberstein. This is the great centre of the agate industry of the world, and the art of cutting these hard stones is not only carried to its greatest perfection there, but art has also lent its aid in increasing the variety and beauty of their colours; a large portion of the material shown having been artificially stained. This is said to be accomplished by heating the articles and then plunging them into coloured solutions, or by boiling them in honey or oil, and subsequently by heating them to carbonize the matter absorbed by the more porous bands. All the blue agates, of which there were so many shown, owed their colour to this treatment.

Jasper in many varieties, including the heliotrope, or "bloodstone,"—a green jasper blotched with red,—appeared in fancy articles as parts of many exhibits, but nowhere in quality or quantity that calls for special notice.

7. Opal.—Although the opals which formed part of the exhibits of jewelry will be noticed by others, two quite unusual displays of opals were made in the Exhibition which deserve to be mentioned here. These are, first, the Hungarian opals shown in the Austrian department, and, second, those from Australia, which formed part of the great exhibit of Queensland. The former was particularly interesting, because it included masses of rock traversed by veins of opal, showing fully its mode of occurrence, and the largest homogeneous mass of precious opal known. This was an irregular flattened tablet some four inches long by two inches wide, and between half an inch and an inch in thickness, weighing over six ounces, and valued at $25,000. It was of the finest quality throughout, and all parts of the surface emitted the iridescent reflections so characteristic of this beautiful gem. A larger mass, weighing seventeen ounces, is contained in the Vienna Museum, but it is much fissured, and not perfectly free from rock.

The Queensland opals were for the most part in masses of the matrix, which —and this constituted the special interest of the exhibit—was limonite, the hydrated sesquioxide of iron. Although having considerable superficial area, these opals had generally little thickness, and formed a mere coating or film over the underlying rock. Still, the colours were brilliant, and some of the masses evidently had considerable value as gems.

Some beautiful specimens of the Honduras opals were shown by the jewellers, but the country from which they came had no representation in the Exhibition, and they were not otherwise shown. These, like those of Hungary, occur in veins in an igneous rock, and are fully equal to them in quality.

The opal is undoubtedly the most beautiful of gems, but it is a brittle stone, and is liable to crack from sudden changes of temperature, and even without any assignable cause. In composition it is a hydrated silica, and contains ten per cent. of water; its brilliant colours are due to its mechanical structure,—*i.e.*, to fissures or cavities which decompose the rays of light.

WHETSTONES AND OILSTONES OR HONES.

By James M. Safford.

These are in use the world over for whetting or sharpening edge-tools and for polishing hard surfaces. Some are used dry, others require water and some oil. Their use often follows that of the revolving grindstone. Though generally flat and straight rectangular pieces, they are frequently made of other shapes to suit the instruments to be whetted. They owe their abrading power to the presence in their composition of hard silicious or quartz-grains in preponderating proportion. The quartz may be coarse or fine granular, as in sandstones and some mica-schists, or flint-like (crypto-crystalline), as in many hones. Some are simply quartz rock. *Bats* are whetstones cut from tough and sharply-gritted sandstones, a rock by no means rare. They are in use for sharpening scythes (scythe-stones), mowers, and coarse knives. Whetstones of similar bite, often very sharp and abrading rapidly, are called *ragstones* in Norway, Russia, and Scotland, when made of quartzose mica-schist. Bats, ragstones, and other whetstones, in great number and of all grades, were on exhibition, the material coming principally from various parts of North America and Europe, and, as hand specimens forming parts of collections, from South America, Australia, and other parts of the globe. They require no special mention here. In the United States and Canada there are many localities where either bats or ragstones of good sharp grit have been or can be obtained. The stones should be uniform in texture, have a keen grain, and not be inclined to become smooth or glazed on the surface. The manufacture of such whetstones is already an industry of considerable importance in this country. It could be expanded indefinitely, having a seat at numerous points, were there a corresponding demand.

Hones or oilstones are prepared principally from silicious layers of flint-like or fine granular texture, and are employed when the finest and sharpest edges are desired. In a rock suitable for them, which may be a fine slate or a compact silicious rock, the texture is uniform, hard, and firm, and the grain keen but not easily discernible. Material for the first-class hones is found at but few localities, three of the most noted of which are respectively in Asia Minor, Arkansas, United States, and in the neighbourhood of Ratisbon, Germany. That from Asia Minor, known as *Turkey oilstone*, is considered to be the best of its class. It wears away the hardest steel, and can resist, by its close and compact texture, the pressure necessary to sharpen gravers and the smallest instruments. It is of bluish colour, though some varieties are light-coloured, of close grain, often flawed or cracked, not very tough, and requiring to be backed with slate or wood. The silica of the Turkish stone, present in the proportion of 70 to 75 per cent., appears to be very intimately blended with calcite. The stone is obtained in the interior of Asia Minor, and is brought to Smyrna for sale.

Little inferior, if any, to the Turkey is the best variety of oilstone brought from the State of Arkansas. In fact, the latter commands a higher price in New York than the former. The development of the *Arkansas stone*, and its manufacture into sharpening and polishing pieces of many and varied forms is an industry pertaining, in its beginnings and growth, to the century which has just closed.

There were two tasteful and full exhibits of manufactured Arkansas stone in the Exhibition. We shall speak of these below.

The *German hone*, or "*razor-hone*" (*novaculite*), is from the slate hills near Ratisbon, where it is found, forming a yellowish layer running through blue slate, and varying in thickness from 1 to 18 inches. It is tougher than either of the kinds mentioned, and has a keen bite. The rock is sawn into thin slabs, which are usually strengthened by being cemented to slices of blue slate. Sometimes they are cut out with the blue slate naturally attached.

In addition to the above, oilstones are prepared in Bohemia, Great Britain, Canada, in several States of the Union besides Arkansas, and in other countries. In Great Britain, among others, are the *Charnley Forest stone*, said to be a good substitute for the Turkey stone, the *Welsh slate* or *oilstone*, a tough, fine-grained, silicious slate, and the *Water-of-Ayr*, or *Snake stone*, apparently

an altered shale of grayish mottled colour, and used for polishing copper-plates and ornamental marbles.

The exhibits of Arkansas oilstones, referred to above, were made by two parties,—Messrs. Boyd & Chase, *New York, N.Y.*, and Julius Louis & Brother, *Jeffersonville, Indiana.* In addition to these exhibits, there was an extensive display of the uncut rock in the Arkansas State building. This oilstone material is a white and beautiful silicious rock, often called novaculite, occuring in abundance in the hills of Garland County (formerly a part of Hot Springs County), Arkansas, and on the Washita (Ouachita) River in the same county. The famous Hot Springs are in Garland County, and a ridge or hill from which some of the hot waters flow contains novaculite The rock is of the age of the Millstone grit, at the base of the coal measures, and is thought by some to be a metamorphosed sandstone, the change having been brought about by the "permeation through the mass of heated alkaline silicious waters," such as now flow from the springs, or by water still hotter, and more charged with saline matter.* The following is the result of an analysis made of the novaculite by Dr. D. D. Owen:

Silica	98·00
Alumina, tinged with oxide of iron	00·80
Potash	00·60
Soda	00·50
Traces of lime, magnesia, hydrofluoric acid and moisture	00·10
	100·00

The rock varies at different localities in fineness of grain and hardness, and consequently in value, as an oilstone. The best of it has the whiteness and beauty of the most compact and whitest Carrara marble. It is of very fine grain (approximating chalcedony in this respect), yet with keen grit, is uniformly hard, not readily grooved, and is altogether an admirable sharpening stone for all steel instruments requiring sharp points or fine cutting edges, as well as a polishing stone for small work, such as finishing the steel pivots of watch-wheels and other parts of watches. The best is known technically as the *Arkansas* stone; that of second grade as the *Washita* or *Ouachita.* The former is obtained with difficulty in the ridge at the Hot Springs. It is much fractured in place, and is not easily secured in large pieces free from veins of common quartz. The Washita is a coarser and cheaper stone. It is more porous than the Arkansas, and better suited to the sharpening of ordinary tools. A number of localities supply it. The old Washita quarries are several miles from the Hot Springs.

The exhibit of Messrs. Boyd and Chase, located in the Main Building, was full and highly satisfactory. It included the Arkansas and the Washita grades of novaculite, cut into blocks, slips, rods, pieces, and wheels of the many sizes and forms suitable for the purposes to which oilstones are applicable. The crude material brought from Arkansas, is sawn and worked up at their factory in New York. Their works, established in 1851, are perhaps the most extensive of the kind in the world. They employ 20 men and boys, use an engine of 60 horse-power, and turn out annually products having a value of about $30,000, which are sold in the United States, Canada, England, France, Germany, Switzerland, and other European countries. The following are the prices at which these gentlemen sell their prepared stones, including the Turkey and Hindostan kinds, in which also they deal:

Arkansas oilstone	$1·50 per pound.
Washita „	·35 „
Turkey „	1·00 „
Hindostan or Orange oilstone	4 to 6 cts.

The Hindostan is a water-stone of even and fine grain, obtained in Indiana, United States, and has a good reputation. The preparation of axe-stones,

* See the *Second Report of a Geological Reconnaissance of the Southern and Middle Counties of Arkansas, made during the Years* 1859 *and* 1860 *by David Dale Owen,* pp. 23 and 101.

carpenters' stones, and slips from this material is carried on quite extensively in the State mentioned. It has been shipped to Sheffield, England.* An oilstone from Lake Superior is sold by Boyd & Chase at 20 cents.

The exhibit of JULIUS LOUIS & BROTHER, located in the Main Building, and near that just spoken of, was well worthy of commendation. It presented a series of the manufactured Arkansas and Washita oilstones in variety. It was not so full as that of Boyd and Chase, but otherwise much like it. In addition to the novaculite these gentlemen had an interesting series of *Orange stones* and *slips*, which are used both with water and oil, and are recommended for their good grit and low price. The material is allied to the Hindostan stone, and is well adapted for sharpening and polishing purposes. It is obtained from a quarry owned by the exhibitors, in Lawrence County, Indiana. The Messrs. Louis represent one of the very oldest firms in their line of business. They employ from 10 to 15 hands, according to the demands of trade, use an engine of 10 horse-power, and throw upon the market annually from $10,000 to $15,000 worth of products, which are sold in this country and Europe.

MILLSTONES.

By JAMES M. SAFFORD.

Less than a hundred years ago small wind and water mills for grinding grain were very numerous, and the chief reliance for the supply of flour and meal. The stones for such mills were principally worked out of hard sandstones and conglomerates (millstone grits). Those rocks were preferred which could supply a keen cutting surface, one hard and tough enough to resist wear and to keep from crumbling, so as to do good work without giving off a sensible amount of sand or stony particles to be mixed with the meals. A good material of the kind was in great request, and they were sought for, in England and in this country, among the Palæozoic sandstones. Of late years, however, the milling business has been conducted on a very different scale. The mills have largely become great factories, requiring for their more efficient and greater work heavy stones constructed out of the most suitable material attainable. That preferred is *buhr-stone* or *burr-stone*, a rock found in the Tertiary formations of France, and also, though generally not so good in quality, in the Carboniferous of Ohio and the Tertiary of Georgia and other Southern States. The French rock is described below. The improvements in millstones have had relation to the selection of material, size and strength of stones, nice fitting of parts, disposition of furrows, bolting combinations, and general construction. These advances will be partially illustrated in the notices to follow. The discussion of them would belong, for the main part, to a treatise on milling, which it is not our purpose to write.

The exhibits of millstones worthy of especial notice were made by citizens of France, Belgium, England, Saxony, and Norway. If there were any millstones in the Exhibition from the United States manufactured out of our own material, and worthy of consideration, they escaped our observation. Certainly no notice of the presence of such stones was supplied to us. This is to be regretted, since very fair stones, little inferior to those of French make, and undoubtedly superior to some brought to the Exhibition from Europe, have been manufactured from the buhr-stone of Ohio, the weathered Silurian chert of Tennessee, and from similar material of other States, to say nothing of less valuable ones made from quartzites, hard sandstones, granites, and other hard rocks.

In the matter of millstone material of best quality, France still bears the palm. This material is the well-known cellular silicious rock of the Paris basin, called *buhr-stone*, a flinty mass, often containing fossil shells, and of a chalcedonic nature. Its extreme roughness, hardness, and strength, combined with its cellular character, give it the pre-eminence which it enjoys for milling purposes. The rock is of a grayish or whitish colour, often with a tinge of yellow or blue. Some pieces of the best quality have a bluish tinge.

* See *Seventh Annual Report of the Geological Survey of Indiana*, 1875. E. T. Cox, p. 332.

There are numerous points, not far from Paris, where the buhr-stone is obtained in quarries open to the day. Large quantities of the rock, in pieces or *panes*, are carried to the countries of Europe and America. Manufactured millstones are also largely exported. The burr-rock of the Paris basin is carried to all quarters of the globe, and to nearly all nations visited by the ships of commerce.

The French exhibits were placed in the Agricultural Hall, the following firms being well represented: ROGER, SON, & Co., BAILLY & Co., and ALEXANDER FAUQUEUX, all of whom were established at that important and famous buhr-stone locality, La Ferté-sous-Jouarre, Seine and Marne.

The first of these, ROGER, SON, & Co., a firm founded in 1802, made an extensive and interesting display both of millstones and dressed pieces of burr. The millstones were well made and of good finish. The rock material of excellent quality, uniform in texture and colour, was from the noted quarries of the company. This firm makes use of steam power in its workshops, and employs in its quarries and various departments of the business about 600 workmen. It exports to all parts of the world, and, in 1875, shipped to the United States alone 3,000 tons of merchandise, consisting of blocks of burr and manufactured millstones. Mr. Roger, of this firm, deserves great credit for what he has successfully done towards the dressing of millstones with diamond tools. Two results have been obtained by this practice: first, the stones are well and accurately dressed; and, secondly, which is the more important, as it involves security from disease and the saving of life, the workmen are not exposed to the fine flinty and irritating dust which before they necessarily breathed. For what Mr. Rogers has done in this direction he received in June of this very year (1876) a prize of 4,000 francs from the Société d'Encouragement of France. The following information, supplied to us by the gentlemen of the French Commission, will explain the facts more fully:

"In the manufacture of millstones there is a peculiarly disastrous influence exerted upon the health of the workmen employed, as they are obliged to work continually in a bent position, especially during the dressing process. At this time there is a considerable quantity of the dust of silex produced under the blows of the picks, which, mingling with the air breathed, finds its way into the lungs of the workmen. Consumption soon sets in, and these unfortunate people are brought to an inevitable death at the early age of from thirty to thirty-five years.

"In 1865 the manufacturers of millstones at La Ferté, under the patronage of the Société d'Encouragement, offered a prize to any person who should discover the means of preventing the mortality among the workmen. Monsieur Roger solved the philanthropic problem by suggesting a mechanical process in the dressing of millstones. According to his system the stones are placed on a turning lathe, and dressed by the aid of diamond tools carried on disks, revolving with extreme rapidity. The injurious dust resulting from this operation is absorbed by an aspirator, and the lives of the workmen are no longer jeopardized.

"Moreover, the millstones passing through this mechanical process are dressed in quite a mathematical way. They are turned out perfect,—the hole is then cut, and the stones are ready for immediate use in the mills, where they will at once make good flour. This result cannot be obtained from millstones dressed by hand. The mechanical process must, therefore be considered a great advance, both from an industrial and a sanitary point of view."

The MESSRS. BAILLY, & Co., a house of more than thirty years standing, exhibited among other millstones a pair of stones to which they directed especial attention. Of this pair, the runner (A), of bluish buhr stone, was from La Justice quarry; and the bedstone (B), from le Bois des Chesneaux. These millstones were peculiar, in being made up of small but choice pieces. We are informed by Messrs. Bailly & Co. that "these sorts of stones are "only to be found in small and thin pieces or blocks. Notwithstanding this "undeniable fact, the making up of millstones out of these blocks is so care-"fully attended to, the cementing together and the backing with Portland "cement give them so much strength, and finally the nature of the stone "resists wear so well, that in a well-managed mill these stones will last a

" great length of time, provided care be taken to frequently dress them " in a delicate manner with mill-bills, well-filed and worked by experienced " hands. In countries where the latter cannot be easily found, the best " course would be to dress the millstones with diamond dressing machines " In using these the millstones will keep in a sound state, will not wear out " so rapidly, and therefore will last much longer." The two millstones, A and B, had been dressed and finished, ready for work, by the Rotative Diamond Automatic Universal Machine of Mr. A. Millot, of Zurich, Switzerland, which the Messrs. Bailly & Co. regard as the most perfect machine of the kind. While not depreciating the buhr-stone from other quarries, these gentlemen claim that the small blocks from the quarries of La Justice and Bois des Chesneaux, such as are used in the building up of the millstones mentioned, are of unequalled quality.

For the sake of the general information contained, we give below the table of prices current of Bailly & Co., for millstones and burr-blocks :

Diameters.	Description of Mill and Burr Stones.	A. Selling Price delivered at the Railway Station of La Ferté-sous-Jouarre.	B. Selling Price Free on board at New York.	C. Selling Price landed on the Pier in New York, Duty Paid, as per Tariff of 1874.
		Frs.	Frs.	Frs.
	1st. French Millstones of La Ferté-sous-Jouarre, of superior quality, from the quarries of Justice and Bois des Chesneaux, and similar to those exhibited at the Philadelphia Exhibition, under the marks A and B.			
3 feet 6 inches	Millstones dressed and well finished, per pair	750·00	790·00	950·00
4 „ 0 „	" " "	900·00	950·00	1140·00
4 „ 6 „	" " "	1000·00	1065·00	1280·00
	2nd. Solid Millstones, in one block, of various diameters, from 1 foot to 4 feet 6 inches. Not being dressed or finished, and of the same quality as those exhibited at the Philadelphia Exhibition, under the marks			
1 foot 0 inches	C D, each	8·00	9·80	11·80
1 „ 2 „	"	11·00	13·25	15·90
1 „ 4 „	"	15·00	17·70	21·25
1 „ 6 „	"	19·00	22·15	26·60
1 „ 8 „	"	23·00	26·60	32·00
1 „ 10 „	"	27·00	31·50	37·80
2 feet 0 „	"	31·00	36·40	43·70
2 „ 2 „	"	35·00	41·30	49·60
2 „ 4 „	"	39·00	46·20	55·45
2 „ 6 „	"	45·00	54·00	64·80
2 „ 8 „	"	52·00	62·80	75·40
3 „ 0 „	"	70·00	82·60	99·15
3 „ 3 „	"	88·00	104·20	125·00
3 „ 6 „	"	110·00	129·80	155·75
4 „ 0 „	"	160·00	183·40	220·00
4 „ 6 „	"	200·00	230·60	277·00
	3rd. French manufactured Millstones, of good quality, from the quarries of Epernon, Boitron, &c., and equal in quality to the Burr blocks exhibited at the Philadelphia Exhibition, under the marks E. and F.			
3 feet 6 inches	Millstones dressed and well finished, per pair	400·00	440·00	528·00
4 „ 0 „	" " "	490·00	540·00	648·00
4 „ 6 „	" " "	600·00	660·00	792·00
	4th. Burr blocks, from the quarries of Boitron, Mennecy, &c., similar to those exhibited at the Philadelphia Exhibition, under the marks E and F, per 104 burrs faced	500·00	680·00	No duty.

Payable by drafts on Paris at sixty days' sight from date of orders.

Mr. Alexander Fauqueux exhibited, through his agents, Blake & Walton, of Philadelphia, a number of well-dressed, well-jointed, and finished millstones, together with a suite of burr-blocks. It is sufficient to say that the stone of these was also from the quarries of La Ferté-sous-Jouarre.

Among the French exhibits of millstones, the Bolting Millstone of Aubin (Aubin & Barron, millers, Bouray and Vaux, near Paris) attracted no little attention. This, as the name implies, is a machine combining both grinding and bolting apparatus. Its consideration hardly belongs here, as it is properly classed with other bolting contrivances; nevertheless, since it was placed among the millstones, we shall briefly notice its form and the results sought to be obtained by its use.

This invention was patented August 31, 1875, and has been honoured by the bestowal of two gold medals, the last from the French Society of Agriculture in June 1876. In a pair of millstones arranged for the Aubin bolting process, the upper stone or runner does not differ from the ordinary kind, the modification being confined to the bedstone. In the latter, the furrows are on the radiating system, but every other furrow is replaced by an opening of the same shape, into which is fitted a cast-iron box covered with wire-cloth that acts as a sieve. These boxes are made, by suitable contrivances, to receive slight vibratory shocks as the stone turns, which, with the assistance of a draft of air, causes the fine flour to pass through them to the receiving floor below.

The Aubin bolting-stones are now used in several of the most important mills around Paris. The following results are claimed for the invention:

"1st. A very great economy of motive-power required to grind the same quantity of grain in the same space of time, as the flour as soon as made need not travel to the edge, but falls through the metallic sifting-cloth, thereby enabling the grinding of more grain with the same power.

"2nd. A superior flour is obtained from the fact of its not being uselessly heated and exhausted by the stone, which it leaves as soon as made.

"3rd. The bran, coming out at the periphery without being mixed with the flour, is better cleansed, and consequently comes out lighter.

"4th. Producing a greater quantity of flour, and also a diminution of refuse grain for regrinding. Besides, a certain saving in weight from less evaporation, consequent upon less overheating."

In the early part of 1785, Mr. J. A. Barral, Secretary of the Central Society of Agriculture of France, made a report in reference to the Aubin bolting millstone, which is very commendatory. The following is from the first page of this report:

"We have been for several years aware that Mr. Aubin, in his mills at Bouray, had adopted a new process of milling, which, if successful, would constitute one of the greatest improvements recorded in the production of flour for a long time. Learning that the invention had been brought to a degree of mechanical and practical perfection, we visited the mills at Bouray. Mr. Aubin very kindly gave us a perfect and complete insight into the process, with which we were so highly pleased that we deem it our duty to make a report which cannot fail to interest all concerned in the public sustenance. A few words will suffice to explain the object sought by the invention. When the grain of wheat is crushed between the bedstone and the runner, the bran and flour remain together between the two, until the whole is ejected by centrifugal force along the furrows of the bedstone, to the edge; the whole of the bran and flour must then be subjected to bolting and regrinding. Is it not evident that at a short distance from the centre there is a certain quantity of flour already formed which will be uselessly carried to the edge, sticking and often greasing the roughness of the stone, which has to be so carefully and frequently dressed? A part of the motive-power is thus wasted, and, besides, all the meal remains blended, which prevents the brans from having that lightness which they would otherwise have. To cause the separation of the flour from the bran as fast as it has reached the required state of fineness, and that the bran may be entirely separated on its exit at the periphery of the stones, is the problem which Mr. Aubin has solved in a most remarkable manner."

Mr. Dassonville de St. Hubert, *Namur, Belgium*, exhibited an excellent pair of millstones for grinding wheat. These were built of French burr, from the quarries of La Ferté-sous-Jouarre. Each had a diameter of 1·40 metres, and consisted of a central octagonal piece, to the perimeter of which were adjusted sixteen pieces of uniform shape. The especial merit of the stones consisted in the accurate fitting of the pieces, the joints being scarcely seen, and in the fact that the joints between the outer pieces lay in the grooves of the stone. The latter feature is doubtless a good one, as it secures a uniform working face without joints. It is claimed, with good reason, that this makes the stone more durable, and contributes to the reliability of its work. A pair of these millstones can be sold for 700 francs. The same gentleman exhibited a pair of stones (each stone of one piece) for grinding such materials as Portland cement. These were of Belgian burr or rock, from the province of Namur. Stones of the kind are highly esteemed for the purpose mentioned. They can stand more heat without flying to pieces than those manufactured at other points. They are extensively sold in Germany, France, England, and Belgium, and principally to the manufacturers of cement. This establishment employs about 170 men, and turns out about 600 pairs of stones, the business amounting to 420,000 francs yearly.

From Norway there were two different exhibits of millstones. Mr. Fred. Lönseth, *Christiania*, exhibited specimens of the Saelbo millstones. These are cut in one piece, out of the celebrated Saelbo mica-schist, which is garnetiferous. The surface of the stone was studded with small garnets, and the rock hard and strong. For coarse work this would answer, doubtless, a good purpose.

The Christiania Millstone Factory exhibited four millstones made of French buhr-stone. This factory was established in 1867, by L. Bertol. The imported material is put together and the millstones constructed with reference to their particular use in Norway and Sweden.

To the millstones of French burr must be added two large and well-constructed millstones manufactured by Kay & Hilton, *Liverpool, England*, and displayed in the Agricultural Hall. This firm also exhibited a large shelling-stone, worthy of note. It was made in one piece out of a coarse quartzose sandstone.

A pair of large millstones were also on exhibition in the Machinery Hall, from the house of Israel Brothers, *Dresden, Saxony*. Each was a single piece. They were commended for size and good quality.

GRINDSTONES AND FIXTURES.

By James M. Safford.

The grindstone is an implement of great antiquity, an heirloom of the past, —one which, for its special work, modern mechanism, with all its new appliances and processes, has not been able to supersede. It has always been a "round revolving stone." Nevertheless, the grindstone which satisfied our ancestors would rarely be acceptable to a modern skilled machinist. It is required now, more than ever, that the stone be of a character, as to uniform composition, grain, porosity, hardness, bite, strength, and size, best suited to the particular use in view. A stone good for one purpose is often quite inefficient for another; and Europe and a good part of the United States have been pretty well searched over for grits of various kinds respectively adapted to the many and varied demands of the mechanic arts. It is required also that the grindstone be accurately mounted and dressed. The best are turned in a lathe by means of iron, steel, or diamond tools, and thus made perfectly true.

The utility and importance of the grindstone "could not be guessed at by "one looking at a crooked and badly kept stone. But in the hands of those "who know its merit, with its even surface running as true as any turned "wheel, it will perform work with a rapidity and precision attainable by no "other means. In the hands of those who are learned in its use and keeping, "it is capable of adaptation to intricate and fine work; but with those who

" do not understand it, it is rude, and the very opposite of what the educated " craftsman would select for any purpose of fine employment. It alone can " shape expeditiously that which is prepared to cut and shape all other hard " materials—cast-steel hardened. It is still employed to give the finest edge, " the most even surface, the brightest polish, and is the quickest to accomplish " it. The emery-wheel does but a few of its purposes, and nothing that we " have could supply its place. The file has its own peculiar uses, but in " contact with the grindstone its thousand small cutting edges would be " reduced to polished plainness. It is found a necessary implement on the " farm, and is still required where the finest of instruments are made, " or the hardest of metals are worked."

The most approved grindstone grits of Europe and America were represented at the Exhibition. Most of the best in use in Great Britain, Canada, and the United States were exhibited collectively in a complete and remarkable display of grindstones made by Mr. J. E. Mitchell, of Philadelphia, Pennsylvania. This enterprising gentleman had exhibits in Machinery Hall, the Main Building, Agricultural Hall, and the Shoe and Leather Building. The most striking display was fittingly in Machinery Hall. Grindstones, mounted or unmounted, are considered homely objects, hardly deserving room where pieces of mechanism are sought to be arranged in groups attractive to the eye. Here, however, the energy and taste of Mr. Mitchell had erected out of homely, unmounted stones a beautiful Tuscan column, 26 feet in height, with pedestal and capital, well proportioned, and securing the attention of all passers-by. This column was a pile of grindstones, all of which had been accurately turned by improved methods. They were of different and pleasing shades of colour, and placed flatwise, one upon another. The column displayed nearly forty varieties of machinists' grindstones from different parts of the world, of which the following, including the names and particular uses of the stones and the localities from which the crude material was derived, is a list:

Constitution, building, Ohio.
Constitution, for tools, „
Huron, fine blue, Michigan.
Constitution, saws, Ohio.
St. Geneviève, tools, Missouri.
Macomb, tools, Kentucky.
Huron, tools, Michigan.
Huron, coarse gray, Michigan.
Independence, files, Ohio.
Amherst, blue, „
Amherst, gray, „
Berea, tools, „
Massillon, files, „
Constitution, saws, „
Marietta, tools, „
Ragged Reef, tools, Nova Scotia.
Wilbur, tools, „
Buddros, springs, „
Bay Chaleur, cutlery, New Brunswick.
Bay Chaleur, whitening, New Brunswick.
Lower Cove, tools, Nova Scotia.
Shediac, tools, New Brunswick.
French, white, tools, France.
French, red, cutlery, „
Saxon, white, cutlery, Saxony.
Yorkshire, files, England.
Melling, white, tools, England.
Melling, red, tools, „
Normanton, tools, „
Whitening, cutlery, „
Thriburg, tools, „
Derbyshire, files, „
Yorkshire, tools, „
New Castle, machine-work, England.
New Castle, files, „
New Castle, tools, „
Constitution gray, Ohio.
Amherst, buff, „

In addition to these, and placed around the pedestal of the column, were five sizes of grindstones in cast-iron boxes, with rests and pulleys, finished and ready for use; one double-hung fixture, with two grindstones, one coarse, and the other fine-grained, adjusted to keep perfectly true; five sizes in wood frames ready for use; and 20 grindstones from 1,000 to 4,000 pounds each, of various grits, and turned accurately true. Besides these there were oil-stones, lathe-stones, and other sharpening materials. In the other buildings mentioned this display was supplemented by exhibits of grindstones for farmers', glass-cutters', cutlers', and dentists' uses; of clearing, rub, scouring, and fiddling-stones; and of scythe, oil, whet, and polishing stones and materials in variety, and of the best quality. The establishment which supplied this instructive display was started in Philadelphia about the year 1810, by James

Mitchell, at the junction of Fourth Street and the old "York Road." The buildings erected at that time are still in existence, and occupied by J. E. Mitchell, the son and successor of James Mitchell, who died in 1851. These buildings have since been largely increased in size, and a large factory has been erected on Beach Street, above Green, in which the manufacture of grindstones and grindstone-fixtures is carried on extensively by the aid of steam-power and large lathes, on which the stones are turned off perfectly true and ready for use by means of improved tools and patented machinery. A grindstone of 5,000 pounds can be adjusted on the shaft and made perfectly true in a short time. Small grindstones, through the agency of a patent machine, are made with great speed and perfection and at a small cost. Gangs of saws are attached to the steam-power, by means of which the broken and damaged grindstones are sawed into slabs of various thicknesses, which are placed in a cutting-machine, which makes them into grindstones at the rate of seven in ten minutes. These are used by cutlers for grinding table-knives, razors, &c. A harder stone is imported from Europe in blocks, which are also sawed in slabs of one inch thick and made into the famous Craigleith wheels, the only article yet discovered which will cut glass satisfactorily. The beautiful cutwork on wine-glasses, decanters, globes, and the delicate tracery and landscape on the plate-glass vestibule-doors, are done with this stone. Mr. Mitchell employs from 15 to 20 men. The value of the annual production is about $60,000. The products are sold mainly in Pennsylvania and the adjoining States. The rock-material used is derived from many and distant localities, but Ohio, the British Provinces, and England are the chief sources. It is mainly from strata of Carboniferous sandstones,—the Lower Carboniferous in Ohio and Huron, Michigan, and the Upper in the British Provinces and England. The following summary of the kinds, localities, &c., is supplied by Mr. Mitchell:

English Grindstones.

New Castle.—Yellow colour and sharp grit; the fine soft ones for grinding saws, and the coarser and harder ones for sad-irons and springs, pulleys, and shafting (instead of turning), and for bead and face-stones in nail-works, and for castings (dry grinding).

Wickersly.—Grayish-yellow colour; for grinding saws, squares, bevels, and cutlers' work generally. A very soft grit to avoid taking out the temper.

Liverpool (or Melling).—Of a red colour and very sharp grit; for saws and edge-tools generally. An excellent grit for sharpening axes in ship-yards.

Nova Scotia.—Blue or yellowish-gray colour, and of all grits, from the finest and hardest to the coarsest and softest; the large ones for grinding sad-irons and hinges, springs and edge-tools; the medium and small sizes for machine-shops and for sharpening edge-tools generally.

Bay Chaleur (New Brunswick).—Of a uniform blue colour and soft, sharp grit; for manufacturing table-cutlery, admirably adapted for machinists' tools, and for sharpening edge-tools generally, when a fine edge is required.

Ohio.

Berea.—White colour, fine and sharp grit; for sharpening edge-tools generally.

Amherst (Black River).—Brownish-white colour, soft, loose grit; for edge-tools, and the very soft ones for saws.

Independence.—Grayish-white colour, and coarse, sharp grit; for grinding springs and files, and for dry grinding of castings.

Massillon.—Yellowish-white colour, coarse, sharp grit; for edge-tools, springs, files, and nail-cutters' face-stones, and for dry grinding of castings.

Huron (Michigan).—Of a uniform blue colour, and fine, sharp grit; good for sharpening tools when a very fine edge is required.

Glass-Cutters' Grindstones, of New Castle, Warrington, Craigleith, and Yorkshire grits; for checkering, mitreing, fluting, and for punty-stones.

Cutlers' Grindstones, of New Castle, Nova Scotia, and Wickersly grits; made to order, of any size.

Shank Stones; for table-cutlery.

Curriers' Rubstones, of New Castle, Nova Scotia, and Ohio grits; for first and second stones; and Scotch Water of Ayr, Welsh, and Hindostan, for clearing-stones.

Scythe, Oil, and Whet Stones.—Ouachita, Arkansas, Orange, and Scotch Water of Ayr stones and hones, of all shapes. Shoemakers' rubbers, and scythe-stones of all sizes.

Grindstones are hung by Mr. Mitchell on a round wrought-iron shaft passing through a round eye. A screw is cut on the shaft and fitted with a heavy nut, by means of which two iron plates are made to press against the sides of the stone. By this arrangement the stone is held by pressure and friction alone, thus relieving the eye from all strain, and very much diminishing the tendency to burst, besides admitting of nice adjustment. This method is a great improvement on the old style of hanging the grindstone on a square shaft wedged into a square hole, whereby the risk of bursting is greatly enhanced. Credit is due for the character of the boxes in which the stones are hung. These are made with cast-iron sides, bolted against a galvanized iron plate, making a light yet strong box, at the minimum cost. In addition, the excellent finish of the grindstones by means of patent stone-turning tools, and the adaptation of the grain or grit of the stones for the purposes intended, are points worthy of honourable mention.

Messrs. Worthington & Sons, *North Amherst, Ohio.*

This firm exhibited a large, massive, and tasteful pyramid made of thirty grindstones, the heaviest of which, at the base,—No. 1.—was 80 by 13¾ inches. Nos. 2 and 3, counting from the bottom, were each 75 by 12 inches. From these the grindstones of the pyramidal pile decreased regularly in diameter, the one at the top being only 6 inches across. The stones were of different sizes and grits, graded for various uses. Commencing at the bottom of the pyramid, the purposes for which the larger ones were respectively intended are as follows: the grinding of springs, axes before tempering, axes after tempering, saws, tools, cutlery and tobacco-knives, machine-shops, planer-knives; then a set, from 40 down to 30 inches in diameter, for mechanics' and farmers' use. These grindstones were principally from the celebrated quarries of Amherst, Ohio.* Some of the smaller ones, including specimens of superior scythe-stones, came from Huron County, Michigan. The quarries of this stone are near or on the shores of Lake Huron. These gentlemen had on exhibition other grindstones of great size. Their works, which include the business of quarrying and supplying building-stones, located at Amherst and Brownhelm, Ohio, can supply annually 10,000 tons of grindstones, and 300,000 cubic feet of building-stone. They employ 450 persons, who are provided with comfortable houses in a healthy location, with access to good schools. The value of the annual production is $300,000, the products finding a market in the United States and Canada.

The Amherst Stone Company, *Cleveland, Ohio.*

Six large grindstones were exhibited from the quarries of North Amherst. The rock from which they were made is a pure sandstone, of good grit, free from oxide of iron, mica, and calcareous matter, making it refractory and weather-proof. "By the Government test the strength of the rock is from 6,000 to 10,000 pounds to the square inch."

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* The Amherst stone, as well as that quarried at North Amherst, Berea, Independence, and other points in this portion of Ohio, famous not only for grindstones but as a building material as well, is obtained from a bed of sandstone about 60 feet thick, at typical localities, and named in the *Ohio Geological Reports* the Berea grit. It is a member of the Waverly series. A full description of this rock, together with its geological and economic relations, may be found in the above-mentioned *Reports*, vol. ii., Geology, pp. 88 and 216-219. The Huron rock of Michigan lies in the same geological horizon.

THE WORTHORST COMPANY, *Massillon, Ohio.*

A very good and ornamental display of building-stone. In this group the same firm exhibited two grindstones—one for wet and the other for dry grinding—as specimens of their grits, the merits of which are acknowledged by machinists. The quarry of this Company is within the city limits of Massillon. The stratum supplying the material presents an available working-face of nearly 40 feet, and lies just above the first bed of coal. From 75 to 150 men are employed. About 2,500 tons of grindstones, with very many car-loads of building-stones, are annually shipped off. The Massillon rock is of coarse, porous texture, sharp grit, and varies in hardness, No. 1 being the softest and No. 4 the hardest. Nos. 1 and 2 are used for dry grinding. The stones of this company are mostly used by plough, stove, and sad-iron manufactories, spring and file grinders, and rail-mills. Upon analysis the rock is found to consist of 96 per cent. silica, the small percentage of impurity being alumina and iron oxide. It is tender when green from the quarry, but hardens upon exposure.

C. B. WELLS, *Marietta, Ohio.*

These were small grindstones placed in the Ohio geological collection, and made of the sandstone known as "Constitution stone," also used as a building-material, and commended for its attractive colour, fine and uniform grain, and strength.

In addition to the above, there were exhibits of grindstones—generally of limited extent—from Indiana, Illinois, and other States, also from Brazil, Canada, England, Germany, Sweden, and Spain, together with small hand specimens of grits from other countries. Nearly all of the grindstones had some merit to recommend them, and received favourable reports.

KAY & HILTON, *Liverpool, England.*

Two stones, one of superior quality for fine edge-tools, the other suitable for coarser work.

THE GOTTLAND GRINDSTONE COMPANY, *Burgsvick, Sweden.*
J. W. KLINTBERG & Co., *Wisby, Sweden.*

From Sweden came a lot of grindstones, mounted and unmounted. The rock out of which they were manufactured is of even texture and good, sharp grit. The Gottland Grindstone Company began work in 1873, and have annually manufactured grindstones amounting in value to $16,600 in gold. The stones are exported to Denmark, Finland, Russia, and Germany. A grindstone for coarse work, from Lugnas, Sweden, was placed in the Exhibition by Karlson, Gust, & Martin. Such stones find a market in Sweden and the eastern part of Norway.

EMERY AND CORUNDUM.

By JAMES M. SAFFORD.

There were commendable displays of crude and prepared emery and corundum in the Exhibition, the material coming from Greece, Turkey, and the United States. We shall refer to the particular exhibits presently.

As a matter of commercial importance, the use of emery and corundum as abrading materials is a development of the century which has just closed. The lapidaries of the Greeks and Romans in all probability employed the emery of Asia Minor in cutting hard stones, in which they had no little skill; but the quantity used by them, and by those who followed them for hundreds of years, is insignificant in comparison with the many tons annually used now. For several centuries before the year 1846 emery was supplied to the arts almost entirely from Naxos, an island of the Grecian Archipelago. It was easily obtained here, and of good uniform quality. About the year 1800 the price was from $40 to $50 per ton, and between 1820 and 1835 at times even less. At this period "the monopoly of the Naxos emery was purchased "from the Greek Government by an English merchant, who so regulated the "quantity given to commerce that the price gradually rose from $40 to $140 "per ton, a price at which it was sold in 1846 and 1847." In the latter part of 1846 and the early part of 1847, Dr. J. Lawrence Smith commenced

examining and developing the emery formation of Asia Minor, until then unknown. His discoveries and developments had very soon a great effect upon the trade in emery. It began to assume for the first time commercial importance,—an importance that has ever since been growing greater from the impetus then given. Dr. Smith made a report to the Turkish Government; the monopoly of the emery of Turkey was sold to a mercantile house in Smyrna; and the price, in the English market, fell immediately to $50 and $70 per ton, according to the quality. At the present the price is three or four dollars less than this. In 1848 the annual consumption was about 1,500 tons; now it is not far from 5,000 tons. Most of the crude emery is shipped directly to England.

The researches of Dr. Smith in Asia Minor not only gave commercial life to the emery trade in the East, but the facts that he observed have led to other important results. As one of these, we may mention the discovery of the emery vein of Chester, Massachusetts. Dr. Charles T. Jackson, who was the principal agent in making known the vein, says,* "I found that the "minerals, *margarite* and chloritoid (collected at the locality), in talcose, "hornblende, and mica slate rocks, indicated the occurrence of emery, the "association of the rocks and minerals being identical with conditions known "to exist in the localities of emery in Asia Minor." These "conditions" being appreciated by Dr. Jackson and recognised at Chester, caused him to persevere until the vein was found.

In July, 1850, Dr. Smith read a very important memoir on emery before the Academy of Sciences of the French Institute, the substance of which was based on his observations in Asia Minor.† In this are given the localities of emery in Asia Minor and the neighbouring islands, conclusions with reference to the geology of emery, its mineralogical position and characteristics, chemical composition, the method of mining, commercial relations, and, in a second part, an article on the minerals associated with emery. We do not propose to reproduce this matter further than we have already done, and would refer the reader to the memoir. In a subsequent article on the emery mine of Chester,‡ Dr. Smith gives a tabular statement of the analyses, hardness, and specific gravity of specimens of emery and corundum, most of which he had published before. This, as arranged in Dana's *System of Mineralogy*, is here presented. The column of hardness (H) gives the effective abrasive power of the powdered mineral, that of sapphire being 100, determined according to the method described by Dr. Smith in his memoir.

	H.	G.	Al_2O_3.	Iron ox.	CaO.	SiO_2.	H_2O.	
1. Sapphire, India	100	4·06	97·51	1·89	—	0·80	—	=100·20
2. Ruby, „	90	—	97·32	1·09	—	1·21	—	= 99·62
3. Corundum, Asia Minor	77	3·88	92·39	1·67	1·12	2·05	1·60	= 98·83
4. „ Nicaria	65	3·92	87·52	7·50	0·82	2·01	0·68	= 98·53
5. „ Asia	60	3·60	86·62	8·21	0·70	3·85	1·66	=101·04
6. „ India	58	3·89	93·12	0·91	1·02	0·96	2·86	= 99·07
7. „ „	55	3·91	84·56	7·06	1·20	4·00	3·10	= 99·92
8. Emery, Kulah	57	4·28	63·50	33·25	0·92	1·61	1·90	=101·18
9. „ Samos	56	3·98	70·10	22·21	0·62	4·00	2·10	= 99·03
10. „ Nicaria	50	3·75	71·06	20·32	1·40	4·12	2·53	= 99·43
11. „ Kulah	53	4·02	63·00	30·12	0·50	2·36	2·36	= 98·34
12. „ Gumuch	47	3·82	77·82	8·62	1·50	8·13	3·11	= 99·43
13. „ Naxos	46	3·75	68·53	24·10	0·86	3·10	4·72	=101·31
14. „ Nicaria	46	3·74	75·12	13·06	0·72	6·88	3·10	= 98·83
15. „ Gumuch	42	4·31	60·10	33·20	0·48	1·80	5·62	=101·20
16. „ Kulah	40	3·89	61·05	27·15	1·30	9·63	2·00	=101·13
17. „ Chester	38	—	44·01	50·21	—	3·13	und.	—
18. „ „	40	—	50·02	44·11	—	3·25	„	—
19. „ „	39	—	51·92	42·25	—	5·46	„	—
20. „ „	45	—	74·22	19·31	—	5·48	„	—
21. „ „	—	—	84·02	9·63	—	4·81	„	—

* *American Journal of Science*, 2nd Series, vol. xxxix. p. 87.
† Published in the *American Journal of Science*, 2nd Series, vol x., p. 354, and vol xi., p. 53.
‡ *American Journal of Science*, 2nd Series, vol. xlii., p. 83.

The localities Kulah, Gumuch, and the island of Samos belong to Asia Minor; Naxos and Nicaria are islands of the Grecian Archipelago; Chester is in Massachusetts.

From the table it is seen that all the varieties of corundum, excepting the sapphire and ruby, contain water; and, furthermore, that the corundums and emeries, other things being equal, containing the least water are the hardest.

Emery is granular corundum of black, grayish-black, or bluish-black colours, and contains intimately-mixed magnetite or hematite. It may be fine or coarse-grained, and often looks and feels like a black, fine-grained iron-ore, from which it may be distinguished by its scratching agate, and by its low specific gravity. Pure corundum, when in the proper granular condition, is a better abrasive material than emery. Its masses are, however, frequently cleavable, which forbids its preparation into the suitable roundish grains required in the arts.

Corundum (sometimes in the form of emery) has been discovered at many points in the United States, and mostly within a long strip of country extending from Massachusetts to Alabama, and principally in what has been called the great chromiferous serpentine or chrysolite belt. The most numerous localities are in North Carolina. We are fortunate in having an elaborate and able account of the occurrence of corundum at the different localities in the long extent of country mentioned by Professor F. A. Genth.* Dr. C. T. Jackson,† Professor C. U. Shepard,‡ and Dr. J. Lawrence Smith§ have also contributed valuable papers on the Massachusetts, North Carolina, and Georgia corundums. In his last article Dr. Smith points out the parallelism in the geology of the North Carolina and Turkish localities. The chrysolite or serpentine rock of the one region takes the place of the limestone of the other as the gangue rock of the corundum. Very fine masses of corundum, in some instances of large size, weighing six to eight hundred pounds, having fine, large cleavages, are met with in North Carolina.‖ The variety and beauty of the specimens are said to be greater than at any other known locality. They excel in colour, being gray, green, rose, ruby-red, emerald-green, sapphire-blue, with other shades to colourless. Some pieces have been cut and polished, making fair gems, but showing too many flaws to be of any great value. Notwithstanding the extensive development of the mineral in North Carolina, Georgia, and Alabama, it has not, as yet, proved to be of special interest to commerce or the arts.

The Grecian and Turkish emery is shipped in masses of various sizes, from 150 pounds in weight down to pieces the size of an egg. In its preparation the masses are broken up under steam hammers, or hand-sledge hammers, until of a proper size to be placed in the Blake rock-crushers, which reduce the emery to fragments as small as walnuts. These are placed under stampers, rollers, and crushing-machines until the whole is reduced to the required fineness. It is then conveyed to the sifting-machines to separate the various grades of grain. The meshes of wire (or lawn for the finer) used for obtaining the various grades vary from sixty to many thousand holes to the square inch. The grades have sizes and numbers corresponding respectively to the number of meshes in a lineal inch of bolting-cloth. The very fine emery is suspended in water and then assorted by precipitation. The finest floats in the atmosphere of the stamping-room, and is deposited on the beams and shelves, from which it is occasionally collected. Many difficulties beset the manufacture of emery-grains and flour. As a measure of safety, consumers should buy from trustworthy houses. It is always economy to purchase the best article, though it may appear high-priced. This is true of many manufactured goods, but especially so of emery.

The exhibits of Grecian and Asiatic emery in the Exhibition were quite satisfactory. John Oakey & Sons,¶ *London, England*, had in Machinery

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* *Proceedings of the American Philosophical Society*, Philadelphia, xiii. 361, 1873.
† *American Journal of Science*, 2nd Series, xxxix. 88.
‡ *Ibid.*, 3rd Series, iv. 109 and 175.
§ *Ibid.*, 2nd Series, xiii. 83, and 3rd Series, vi. 180.
‖ Credit is very justly given to the Rev. C. D. Smith, of North Carolina, for the discovery of the corundum belt in North Carolina, Georgia, and Alabama.
¶ Geo. H. Gray & Danforth, Importers, Boston, Massachusetts.

Hall a neat exhibit of the Wellington Mills emery grains and flour, with which were two large pieces of Naxos emery, and also a series of polishing-powders. The grains and flour, elegantly displayed in thirty cups exhibiting the different grades manufactured, were commended for uniformity of size, sharp grit, and freedom from foreign substances, the material being of best quality. The Wellington Mills recently constructed, the old buildings having been found insufficient, cover more than an acre of ground. The site "has a "frontage of 155 feet on Westminster Road, and runs back along Mead's "Row for a distance of 340 feet. The plan is that of a hollow square, with "the warehouse and offices fronting the Westminster Road, the factory "premises on the other three sides, and the chimney-stalk, boilers, engines, "and stampers in the centre. . . . . The machinery is worked by three "engines, of which two, of 20 horse-power each, are in the wings, whilst the "third, of 40 horse-power, is placed in a separate building within the square "above mentioned." The Wellington Mills consume about one fourth of all the crude Turkish and Grecian emery that is yearly mined. The prepared emery is sold throughout Great Britain and her colonies, the United States, Canada, India, China, Japan, and other countries. It is used very generally for cutting, grinding, and polishing purposes. Manufacturers of plate-glass, emery-wheels, emery-paper and cloth, edge-tools, cutlery, agricultural implements, machinery, &c., consume it in large quantities.

In the Main Building was another interesting display of Turkish emery, crude and manufactured. This was made by the WASHINGTON MILLS MANUFACTURING COMPANY, *Ashland, Massachusetts*. The series of grain presented included samples free from foreign substances, of even grade, sharp, and of superior quality generally. This company bring to bear an experience of about thirty years. They work up from 400 to 600 tons of crude emery per annum, the products having a value of $150 per ton. They have a range of buildings 400 feet long by 40 wide, with machinery sufficient to manufacture 800 to 1,000 tons per year. The machinery is run by water-power, there being three turbine-wheels in use, equal to 70 or 80 horse-power. Ten men are usually employed. The emery prepared by this company is mainly consumed in the United States, and for the purposes specified above.

The VITRIFIED WHEEL AND EMERY COMPANY, *Ashland, Massachusetts*, had in Annex No. 1 of Machinery Hall a case of manufactured Turkish (Ephesus) emery. The display was creditable. The grains were of good form, free from dirt, and of assorted sizes, running down to the finest flour. In addition there were large specimens of uncrushed emery. Also, in Machinery Hall, in connexion with a display of emery-wheels, the UNION STONE COMPANY, *Boston, Massachusetts*, presented a series of grains and flour of superior Turkish emery. The emery-wheels of the two companies just mentioned were objects of much interest, but their consideration belongs to another group.

In the mineralogical collection of the Turkish department of the Exhibition there were eight very small pieces of emery. These were labelled Tiré & Souke, Province of Aydin. Turkey could have well and appropriately afforded an extensive and varied exhibit of crude emery, such as would have attracted notice and been highly instructive.

JAMES C. HAND & CO., *Philadelphia*, agents for CHANDLER & BALL, manufacturers, *Kennett Square, Pennsylvania*, made a full and interesting exhibit of Pennsylvania prepared corundum. The grains and flour displayed in the Main Building were tastefully arranged in bottles and in casks with glass heads. This corundum was from the Unionville Mine, in Chester County, Pennsylvania. Dr. F. A. Genth*, speaking of this corundum, says, "Loose masses of a brownish-gray granular variety, sometimes of several tons "in weight, had been occasionally met with at the same locality. About two "years ago the deposit from which the masses evidently came was discovered. "It was at the time of my visit exposed to a length of thirty feet, a thickness "of from five to ten feet, with a depth of about fifteen feet. This is a very "important discovery, and the appearance of the deposit or bed leads to the "conclusion that it is the nucleus of unaltered corundum in a mass of

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* *Preliminary Report on the Mineralogy of Pennsylvania*, 1874, p. 33.

" chlorite slates and other rocks which have resulted from its alteration. " From present indications this corundum mine appears to be one of great " value, and promises to furnish large quantities of mineral of very superior " quality."

Dr. Genth then adds, in substance, that the less cleavable a corundum is, the better is its cutting or polishing power, the prepared grains being roundish and presenting good sharp cutting edges. "This latter is the case with the " coarse, granular variety from Unionville, more than with that from any " other part of the world."

The best of the Unionville corundum is superior to the choicest Turkish emery. It is supplied graded like emery. Grains in casks of about 350 pounds each sell at 11 cents per pound, and flour in casks at 9 cents. The capacity of the works is 500 tons of prepared emery. This industry is in its infancy, and no definite information can be given as to the annual production. The mine and the mill have not been worked steadily. The market is chiefly in the United States. Some of the corundum has been sent to England.

Awards were granted, respectively, to J. T. Ames, *Chicopee, Massachusetts*, for an interesting and complete series of the emery of Chester, Massachusetts, with its accompanying rocks and minerals, and to C. W. Jenks *of Jenks' Mine, Macon County, North Carolina*, for an instructive series of the corundum of North Carolina, and associated mineral species. These exhibits were embraced in the Smithsonian collections. At one time it was hoped that the emery and corundum of Chester, Massachusetts, would supersede that of Turkey, but the latter, on account of its better quality, still controls the market. The Chester deposit is a remarkable one. Dr. Genth says of it, " It consists of crystalline corundum in a fine scaly chlorite, or of a peculiar " mixture of granular and crystallized corundum with magnetite (which is " generally titaniferous), intermixed with more or less of a chloritic mineral. " The deposit traverses two mountains for about four miles, with an average " thickness of four feet, and lies in a talcose slate and serpentine, between " gneiss and mica slate, in the centre of the Green Mountains. The gneiss " contains no corundum. The talcose rock, however, has grains of emery, " corundum, and magnetite disseminated through the whole mass. A vein " of oligoclase (so-called indianite) many inches in thickness, with small " particles of corundum diffused through it, runs for many rods through the " chloritic rock. We have already spoken of the North Carolina corundum. " Had this generally a desirable granular structure, its commercial importance " would be at once insured. Much of it, doubtless, is valuable."

In addition to the exhibits of corundum as an abrading material, there were displays of crystals (including Oriental rubies and sapphires) from different countries. Russia exhibited fine crystals of corundum. But to notice these does not come within our province.

MERCURY.

By Daniel De Cortazar.

Mercury is the only metal fluid at the ordinary temperature; it is of a silver-white colour and of great brilliancy. It may be solidified at a temperature of—40° Fah., being then ductile and malleable, like lead, and crystallized in regular octahedrons. In the fluid state and at the temperature of 32° Fah. its gravity is 13·49. It boils at 77° Fah., and gives off fumes at the temperature of 70° Fah.

The chemical equivalent of quicksilver on the hydrogen scale is 100. Mercury has a deleterious action on the organism; in damp air it oxidizes somewhat; nitric acid attacks it at all temperatures, while sulphuric acid only dissolves it when concentrated and warm, and hydrochloric acid has no marked action on it.

The principal value of quicksilver for industrial purposes is its power of combining under certain conditions with gold and silver, separating them from their ores and forming a solid alloy of indefinite composition called "amalgam," which afterwards, if subjected to distillation, sets the gold or silver free. On this quality is based the principal metallurgy of these metals.

Notwithstanding that chemistry possesses many compounds of mercury, nature presents as real ores but native mercury and cinnabar. The last named is a combination of mercury with sulphur, whose formula may be expressed by HgS, which contains 84·5 per cent. of mercury.

Cinnabar is the ore which almost exclusively yields the mercury employed in the arts, and it is not therefore surprising that the greater part of the specimens which were exhibited at the Exhibition of Philadelphia were of this compound.

We will mention in the first place the nature of the ores of mercury exhibited at the Centennial Exhibition, show their importance, and give the localities whence they came, and afterwards analyze the state of the mining and metallurgical industries of mercury as they at present exist.

Spain without doubt presented at the Centennial Exhibition the best and richest samples of mercurial ores. The directors of the well-known Almaden Mines sent to Philadelphia a complete collection of the various ores, classified according to their richness, from crystals and compact cinnibar to sandstones and slates in which the mercury was found in small globules or the cinnabar was seen in nearly imperceptible spots in the rock. They also presented the rocks of the country in connexion with the mercurial ores, the metal obtained, and the models of the *aludels* or small clay vessels, of a special form, in which the condensation of mercury takes place, as well as statistics, plans of the mine and furnaces, by which the extent of the workings and importance of the mine, the profits, and all the circumstances belonging to an establishment of great interest, could be seen at a glance. Spain also exhibited mercurial ores and a sample of metal obtained from the mines of Mieres, in Asturias, all exhibited by Mr. Diestro y Laza; and besides these, there were specimens from the mines of Lucar, in Almeria, displayed by Mr. Daza, and others from Pitres, in Granada, sent by Mr. Vazquez. The two latter exhibits were scarcely worthy of notice.

Very few exhibits of mercurial ores were to be found in the Department of Mines and Metallurgy of the United States; but, fortunately, the members of the Smithsonian Institution had collected in the Government Building several samples from the California and Nevada mines, especially of compact and earthy cinnabar, and others in which the quicksilver was mixed with sulphur, all showing the richness of the mines whence they had been taken. It was much to be regretted that the ores were not accompanied by the rocks in which the mercury is found, and also that the plans of the mines and the statistics of production were lacking.

The Central Pacific Railway Company exhibited in Agricultural Hall some very interesting specimens of mercurial ores, which came from Wallstreet, in Lake County, California; some of them were composed of selenide of mercury.

The samples of cinnabar and the products of quicksilver exhibited by the Imperial and Royal Metallurgical Direction of Idra and Austria were of little value.

The specimens exhibited by the Special Commissioner to the Exhibition from Lima, in Peru, others by the proprietors of the Wilkinson Mine, in Kilkivan, about fifty miles from Maryborough, in Queensland; one of cinnabar, displayed by the Commissioner of the Netherlands, and another of quicksilver, sent by the Brazilian Commission to the Exhibition, were scarcely worth notice.

Some mercurial ores were also sent to the Main Building by the Mexican Republic, and among them the *Livingstonite* exhibited by Mr. Barcéna, of Mexico, attracted general attention. It is a new mineral, composed of sulphur, antimony, and mercury, which, according to the statements made occurs in great quantities.

There were also some good specimens of cinnabar from Pregones, in the State of Guerrero, exhibited by Mr. Folsa, though they did not appear to be very rich. The lack of information prevented me from judging of the real value of the mines from whence they were taken.

This is, in few words, the whole state of the mining and metallurgy of quicksilver as it was represented in the Centennial Exhibition.

We will now say something about the proceedings or means used in the principal countries that produce mercury for obtaining it from its ores.

To extract the quicksilver from its ores it is sufficient to submit them to a roasting process, using at the same time an agent to take out the sulphur. This agent generally consists of lime, when the operation takes place in a closed apparatus, obtaining sulphide of calcium and mercurial vapour, which is afterwards condensed. The air is nearly always the desulphurizing agent, and by its action at a high temperature forms sulphurous acid and mercurial vapour, which is condensed, and the former escapes in the atmosphere.

Notwithstanding the simplicity of the metallurgy of quicksilver in practice, it has not as yet been found possible to solve the problem of the complete condensation of mercurial vapours. The various processes invented for this purpose consist either in dividing the current of gases, causing them to pass through narrow passages, which, being in contact with the air, naturally cools them, or in making the mercurial vapours run through spacious chambers and galleries in order to condense them. Another process is to condense these vapours in tubes sunk in water, or cooled by an apparatus from which a slight and continual flow of water falls upon them. And, lastly, the mercurial vapours have been caused to pass through cold water, which has to be renewed from time to time, and by which the process of condensation is accomplished.

The principal factories of quicksilver are to be found in Almaden. in Spain; in Santa Clara County, California, in the United States; in Idria, Austria; and the Duchy of Zweibruecken, Bavaria. It is said that lately quicksilver ores have been plentifully found and are being used in Borneo.

In Bavaria the ores consist of sandstones spotted with cinnabar, and belong to the Carboniferous formation. The ores, after a concentration, and being mixed with lime, are introduced in retorts, which are placed in two rows in a furnace, the temperature of which being gradually raised, the lime unites with the sulphur of the cinnabar and the quicksilver is volatilized. The mouths of these retorts communicate with earthen receivers placed outside of the furnace, in which there is a certain quantity of water, in which the mercury is condensed.

The late Dr. Ure suggested and carried out a great improvement in the distillation of mercurial ores in the works of Obermoschel by using common iron gas retorts, the hinder parts of which were made movable for the purpose of charging and discharging; and in the forepart of each retort there was a pipe to conduct the vapours into a general condenser, formed of a large tube of cast iron nearly filled with water, in which the quicksilver is condensed, and the other gases formed during the operation go off, after passing through the water.

A very similar process to that above mentioned is used in Idria in the treatment of rich ores and soots; the condenser does not contain water, but is sunk in a receiver which does contain it, the object being to avoid the contact of the mercurial vapour, with the liquid, which, according to some authors, is prejudicial to a good condensation.

In all the methods indicated, the desulphurizing agent is lime; but in nearly all the principal works where mercury is obtained, atmospheric air is used for the purpose of desulphurizing. Thus in Altwasser (Hungary) gray copper ores occur mixed with cinnabar, and these are obtained as a secondary product of the distillation of the ores. The apparatus in which this takes place consists of large chambers surrounded by walls, which are perforated a little above the floor, in order to admit the air. The minerals are put into the chambers in alternating layers with the fuels, and when the combustion commences the mercury in the cinnabar is volatilized, and sulphur goes off in a state of sulphurous acid; while the former is condensed in the upper part of the heap, mixing with the ores from which it is separated by washing, the residues are smelted to obtain the silver and copper which they contain. By this method, imperfect as it is, the greater part of the quicksilver contained in the minerals is saved, the losses not exceeding 12 per cent., and the consumption of fuel being two cubic yards of coal and three of wood for every ten tons of mineral.

In Idria (Austria) the ore is cinnabar, which is found very irregularly impregnating slates and limestones, probably belonging to the Triassic system. The richest ore occurs in the slates. The poor ores are concentrated by a complicated preparation until they yield a medium richness of 6 per cent.

After many trials the system at present used is the employment of furnaces similar to those used in the roasting of copper ores, but in which an almost continuous operation goes on; it only requires the placing of a hopper in the roof through which the charges pass, and removing the residues after the distillation by means of a lower opening. The furnace communicates with a small chamber, and this in its turn with three cast-iron pipes three feet in diameter, and in the form of a very flat V, which collect the quicksilver, which is condensed in them not only by atmospheric influence, but also by the cooling due to an artificial shower produced by an upper apparatus. The large cast-iron tubes lead into a compartment divided into four chambers, and communicating with a chimney separated in the middle by a thin wall, for the purpose of retarding the current of cases and completing the condensation. By this method the working of 200 pounds of ore costs 19 cents, and nearly 4 pounds of quicksilver are obtained from this quantity of ore, losing 29 per cent. In the same establishment of Idria the poor and large ores are utilized in furnaces very similar to those used in Styria and Carinthia for calcining iron ores. The apparatus is constructed of sheets of iron united by rivets; and in the interior is a coating or wall of fire-bricks. The condensation, which was formerly effected by means of a series of chambers, now takes place in tubes similar to those employed in the other furnaces, and the quicksilver is easily condensed in them by the low temperature of the pipes, which are cooled by water falling upon them. The working of 200 pounds of ore in these furnaces costs 18 cents, producing more than 2 pounds of mercury, while there is a loss of 39 per cent. Notwithstanding that the treatment in the last-named furnaces is more advantageous than in the first-named, they are not always used, because the fine ores cannot be treated, nor the soots produced by either method, which are collected either in the iron tubes, in the chambers, or in the chimneys.

The ore produced from the mines of Santa Clara County, in California, is cinnabar mixed with a small quantity of mispickle and gray copper ore. Ferruginous slates, often very brittle, from the vein-stones, and are accompanied by lime and sandstones, and all these rocks are altered by an eruption of serpentine. When the minerals are taken from the mine they are broken and classed, the smaller and poorer ones being separated to enrich them by washing. The first method employed for obtaining the quicksilver contained in the ores was the Bavarian, which was done by mixing the minerals with lime and charging the mixture into retorts; but as this proceeding requires a great deal of manual labour, it has been replaced at the mines of New Almaden by furnaces with condensing chambers similar to those which were formerly employed at Idria, but with interesting and advantageous modifications. The furnaces consist of lateral fire-bars, in which pine-wood is burned, and the flame and gases of the combustion pass through a curved wall by means of several openings, thus passing through the ore, which is placed in the furnace through two upper doors, that are hermetically closed as soon as the furnace is lighted. The opposite side to that of the fire-bars in the furnace is also curved, but placed in an inverse position to the former; and as it, like the other, is full of openings, the gases from the combustion of the wood and those produced by the calcination of the minerals escape into a large chamber, and afterwards pass into three smaller ones, which communicate with each alternately above and below. In the first chamber the greater part of the soots and all the other substances mechanically carried off by the draught are deposited, and in the chambers which follow nearly all of the quicksilver is collected, for which purpose the floor inclines towards an exterior conduit. In order that the condensation may be complete, the last of these chambers has a communication, by means of a long passage, with another condensing apparatus composed of twelve chambers with arched roofs that communicate with each other alternately above and below in the same manner as those which are situated near the furnace. At the end of this great condenser is placed a chimney thirty yards in height. These condensing-chambers, as well as the furnace, rest upon arches of masonry, the floors of which are formed by cast-iron plates placed in such a manner to form two inclined planes, and in the angle formed by them the quicksilver filtered through the masonry of the furnace is gathered, which, before this was done, was lost. All the mercury collected by this means after-

wards runs into an outer channel. A roasting takes from fifty to seventy hours, according to the hygrometric state of the charge, and when this is finished the furnaces are emptied. During the cooling, which generally lasts about twelve hours, the soots, as well as the quicksilver that is in the condensing-chamber, are collected. The furnaces are of different sizes, but the best are capable of containing 100 cubic yards of ores. A consumption of 34 cubic yards of pine-wood is required for each operation,—that is to say, the fuel is as 1 : 3 in proportion to the ore. A pound of mercury obtained by the use of these furnaces costs about 5 cents, and the whole annual production amounts to nearly 30,000 flasks of 76½ pounds avoirdupois each.

The principal quicksilver mine in the world is at Almaden, in Spain, and its existence has been known from the most remote times. The mine consists of beds of quartzite, more or less impregnated by cinnabar, which appears in two parallel bands of more than 500 yards in length and a variable thickness of from 4 to 30 yards. The quartzites are intercalated between carbonaceous slates containing *graptolites.*

The mercurial ores owe their origin to an eruption of melaphyre, which is called, in the country, *piedra frailesca* (monk-stone), from its colour, and which may be considered younger than the sedimentary rocks in which the mercury is now found. The richness of the ores may be valued on an average at 8 per cent., and after being classed and broken up they are introduced into cylindrical furnaces terminating in a spherical arch. The ores rest in the furnaces upon brick arches, which allow the flame from the fuel to pass, as well as the air necessary to oxidize the sulphide of mercury. Brush-wood is the fuel employed, and this is burned in open grates below the brick arches of the furnaces; the greater part of the products of the combustion goes off by means of a special chimney, and the remainder passes through the ores to roast them. The furnaces communicate, by means of two conduits or passages situated in the base of the arched roof, with the condensing apparatus, which is composed of two systems. One of these, the oldest, is known by the name of its inventor Bustamante, and the other is called "of Idria." The capacity of the Bustamante furnace is about six cubic yards, and that of Idria a little more than double. The charge ore, properly distributed, amounts to nearly ten tons in the first-named furnaces and more than twenty in the latter, consuming two and four tons of brush-wood respectively,—that is to say, the quantity of fuel consumed is one-fifth of that of the calcined mineral. This small consumption is due to the richness of the ores, which only require the sulphur which they contain to commence burning, and with the heat thus liberated the roasting continues. Three days are necessary to conclude an operation in the small furnaces and six in the large ones. In the Bustamante system the condensing of mercurial vapours takes place in twelve rows of earthern tubes, called *aludels*, 18 inches long and 8 to 10 in diameter, which, fitting one into the other, communicate at one end with the furnaces and at the other with a chimney and rest upon two inclined floors of more than 10 yards in length. As the *aludels* are in the open air, they cool, and thus the condensation takes place and the quicksilver issues through a small opening about the one-eight of an inch in diameter, which is situated in the lower part of the earthern tube, and, running over the inclined floors, goes into a general channel which is in the intersection of the floors, and thence by iron pipes to the warehouse, where it is collected, weighed, and packed.

In the apparatus called "of Idria" the condensing operation takes place in twelve large chambers, six on each side of the furnace, covered by arches, and communicating with each other alternately above and below, which oblige the current of gases to run zigzag for a long distance, and which, after crossing an upper chamber provided with a small chimney, issue at last in the air. The dimensions of these chambers are 12 yards in height, 3 in width, and 4½ in length. The mercury which is condensed in each of them runs through a small opening to an outside channel, whence, as in the Bustamante furnaces, it goes into the warehouse.

In these two classes of apparatus an abundance of soots of a complicated nature are formed, and these, after having been deprived of a large quantity of quicksilver which they contain by means of beating upon an inclined plane with a small spade, are mixed with the small ores, and being made into a mass by the aid of water and formed into lumps called *Bolus*, afterwards serve to

form part of the charge of the furnaces. Both Bustamante's and the Idria methods are very imperfect, and there is no doubt that the losses of metal in one and the other are not less than 33 per cent., notwithstanding that of late it has been stated that the former system is an excellent one.

The want of progress existing in this branch in Spain has induced some scientific men to try and discover a more rational proceeding than those at present employed for the treatment of mercurial ores, and one of the principal of those thought of is that of Pellet, so called after the name of a French engineer who invented it. In this process there is a furnace similar to those used in the calcination of iron ores, in which the fuel is brought in contact with the ores. The operation is continuous, and very good contrivances prevent, during the charging and discharging, the escape of vapours which might injure the health of the workmen, and give rise to loss of metal. The condensation is, according to the opinion of several Spanish mining engineers, very ingenious, because the gases are compelled to go into a series of chambers, and in crossing from one to the other of these they have to pass through a sheet of water, always renewed by means of a continual shower, which falls from above, and finally a strong artificial aspiration produces the successive washings, and draws off the gases that cannot be condensed and any undissolved sulphurous acid. Several experiments have demonstrated that in these conditions the gases do not contain any mercury. This system being established, though imperfectly, at a small mine in Argelia, Mr. Pellet received a prize medal in the Franco-Española Exhibition of 1864. In the year 1868 the Spanish Government ordered the construction of a Pellet apparatus in Almaden, on account of the favourable report of the Spanish Mining Commission; and although endeavours have been made to ascertain the difference between the old system and that of Pellet, several circumstances, too long to explain here, have prevented it. In 1870 Mr. Pellet established an apparatus of his system in the province of Granada which gave very satisfactory results, and we have lately heard that the inventor has perfected his system by simplifying it. In short, in Pellet's apparatus the distillation is continuous, the manner of working it very simple, and the cost for 100 pounds of mineral varies from 6 to 8 cents. There is no doubt that this system will be generally used in the metallurgical industry of quicksilver.

Other scientific men of Spain, such as Mr. I. Monasterio, Mr. I. Navarro, and recently Mr. Berrens, have invented more or less original apparatus for the working of mercury, but only that of the last named has been tried, the other systems having been merely proposed.

We will now say a few words with respect to the quicksilver mines.

In describing the establishments in which mercury is obtained, we have mentioned the prominent circumstances of the mines that produce the ores, but in order to complete this report we will pass in a rapid review all the mines which have arrived at a certain importance, although some are abandoned, and others have not as yet been worked.

Leaving aside some mines found in Turkey and Italy, and those lately discovered in Spain, in the provinces of Granada and Almeria, nearly all that have been discovered for the last thirty years are situated in America.

Those of the United States, which merit special attention, are situated some in Nevada, others in Utah, and many in California, always in connexion with eruptive rocks and intercalated in metamorphic slates, and their products make a great competition with the Almaden quicksilver.

In California, the principal mines besides New Almaden are Enriqueta, Guadalupe, Aurora, St. Carlos, and New Idria, all found in metamorphic cretaceous rocks, and in connexion with large eruptions of serpentine. Also to the north of the Bay of San Francisco and the north-east of Pine Mountain, in a region formed by metamorphic rocks and eruptions of serpentine, mercurial mines have been discovered in the environs of Clear Lake.

A short time ago a mercury mine was spoken of in this locality, known by the name of Sulphur Bank, and it is stated that the richness of the mine is very great.

The following is a summary of Mr. Keyes' report of this discovery to the American Institute of Mining Engineers, at the conversazione of the 3rd of

August 1876. The deposit is of sulphur and quicksilver, and with regard to its composition and method of occurrence was not paralleled, so far as he knew, anywhere else in the world:

"This is a deposit of what was thought to be native sulphur, which was first discovered at the extremity of the bay on the east coast of Clear Lake. This deposit, which has since been traced towards the east for over 3,000 feet, lies along on both sides of a fissure, through which in several places thermal springs, containing bicarbonate of soda, free carbonic acid, chloride of sodium, bicarbonate of ammonia, and free silicic acid have been discovered. Explorations, which have been made to a width of 1,000 feet across this fissure, have shown that there is a deposit from 2 to 3 feet thick, which is composed of disintegrated lava mized with a small amount of sulphur and cinnabar, yielding from 1 to 1½ per cent. of mercury. Under this deposit is a bed of impure sulphur from 6 to 8 feet thick. The amount of sulphur in this layer varies from 30 to 80 per cent., the sulphur sometimes being in nearly pure lumps of considerable size. The gangue mixed with the sulphur is similar to that found in the bed above. Lying beneath this sulphur deposit is a bed of lava, which has been found to contain from 1½ to 2½ per cent. of mercury in the form of cinnabar, and also a little sulphur. This bed has been investigated to a depth of 75 feet without discovering its bottom, and is found to cover nearly the whole area along and across the fissure of 3,000 by 1,000 feet. The first efforts made to refine the sulphur found in this deposit were unsuccessful until 1874, when the Sulphur Bank Mining Company began working both for the sulphur and the mercury. The process employed for the extraction of the sulphur is a new one, and for distilling the mercury three apparatus are used. The richer specimens of ores and residues are put into retorts with lime, as is commonly practised at New Almaden. The less pure ore, which is found in lumps, is worked in continuous furnaces, in which it is filled up so as to admit the flame from the combustion chambers between the interstices. The fine ores are worked in a modified Gerstenhöfer furnace. In these continuous furnaces the mercury is condensed in iron chambers, from eight to ten of which are used for each furnace. It is found by experience that the larger each of these chambers is made, the less 'soot' mercury will be found. The passage of the mercurial fumes through these chambers is assured by means of suction currents, produced by Root's blowers, and the draught afforded by a high chimney, to which all the condensers are attached."

With regard to the probable amount of mercury in this deposit, Mr. Keyes said that, according to the estimates of Mr. I. D. Hague and Messrs. Ashburner and Price, the portion already explored, 1,000 by 3,000 feet, contained from 1 and 1½ to 2 per cent. of the metal. This was for a depth of 75 feet, there being no indications that the deposit did not extend even deeper than this. Mr. Vincent, an English engineer, estimates that the same ore contains 2 and 2½ per cent. of mercury, which would make it have a value of $40,000,000 at 50 cents per pound.

"The easy method of mining which is employed, being nothing more than quarrying in benches, combined with the simple furnaces used, have enabled the Sulphur Bank Company to produce the mercury at the low price of 18 cents per pound."

At the time of Mr. Keyes' visit a few months ago, there were from 20,000 to 30,000 tons of lower cinnabar deposits ready to be worked.

In Mexico the quicksilver mines are numerous, though the disturbed state of the country has prevented them from being well known. At all events, it is well to learn that in the Mexican territory there are more than thirty quicksilver mines in the states of Mexico, Jalisco, Guanajuato, St. Luis del Potosi, and Zacatecas. Their richness is very variable, and those that up to the present time have given some good results are those of Capula and St. Romualdo, in the state of Jalisco; Pedemal, Carro, and Guadalcazar, in that of St. Luis del Potosi; and St. Pedro de los Pinos, in that of Zacatecas,—although the whole product together does not exceed 1,000 flasks per annum. There are also mercurial ores in the northern states of Mexico, but their products are unknown in the market. The geological formations in which the quicksilver mines are found in Mexico are very various, for it is said

that the minerals appear in primary, transition, secondary, and tertiary rocks, but it may be stated without doubt that they are everywhere found near eruptive rocks.

In conclusion, we may say that the metallurgy of mercury appears at a stand-still, and no improvements have taken place in it during these past years, in spite of certain trials, such as that of Pellet, which promises in time good results in so important a branch of industry.

Quicksilver mining has really only increased in the United States, and this nation alone produces at the present day nearly the half of the mercury which is used in commerce, and each year the quantity of metal obtained increases; while Spain and Austria remain stationary, and the other countries can scarcely be taken into consideration, on account of their small productions.

We conclude with the statistics of the production of quicksilver in the year 1876 in the whole world:

United States	69,200 flasks.
Spain	41,700 „
Idria	8,000 „
Bavaria	2,000 „
Italy	1,700 „
Borneo	2,000 „
Mexico	500 „
Other countries	1,500 „
Total	126,600 flasks.

of 76½ pounds avoirdupois each.

MADRID, March 1, 1877.

MECHANICAL DRESSING OF ORES AND COAL.

By E. F. ALTHANS.

I. INTRODUCTION.

1. EARLY HISTORY.—Even in the earliest period of mining, where simple manual labour was insufficient, mechanical arrangements—hammers, mortars, mills for the reduction of the gangue obtained in the mine—have been used to separate the useful ore from the accompanying dead-rock, or from the attached foreign ore, and then, by aid of water on sieves or in shallow vessels, viz., percussion tables, (Sichertrögen), or in slime-pits, to wash out the "deads" and the useless, specifically lighter ore, the iron ore, the pyrites, and the blende. To the ores, which in this way are separated with difficulty or not at all, and which are a hindrance in the smelting-furnace or to the quality of the metal, the ancient German miners gave the characteristic nick-names, in use to this day, "blende," "cobalt," "nickel," mispickel." Agricola describes, even in the time of the Reformation, stamp and mill work, jiggers, and the most simple contrivances, similar to the German slime-pit, or the sweeping-table and plane-table, in use to this day, especially in gold washing. The development of machinery began at the time when mining was in the most flourishing condition, before the Reformation, in the alps of Tyrol and Carinthia. The extensive mining enterpizes of the Fugger family, in the empire of Charles the Fifth, gave to these improvements in the art of ore-dressing a wide circulation, even to the rich silver-bearing mountains of the then newly-discovered continent of America. The religious persecution following the Reformation contributed to such circulation. Then, however, the desolating religious war brought mining, formerly so flourishing, almost completely to a stand-still, or left it in a crippled condition nearly everywhere in Europe, and especially in what was then the Germano-Roman empire. The slow renewal of further improvement is due to the revival of mining in Hungary, in Saxony, and in the Hartz, but especially in England, in consequence of the invention and development of the steam engine by Watt and his Cornish disciples. The United States Declaration of Independence occurred at this time. The wonderful advance of machinery has since

elevated to a higher plane the art of ore-dressing also. Still, it cannot be denied that the advance was slow till the last third of the century; since that period, perhaps, till the discovery of the gold treasures of California and the rich deposits of copper at Lake Superior, the art of ore-dressing in the separate mining districts pursued a narrow, exclusive direction, closely circumscribed by local circumstances. A rapid development first began with the general improvement of transportation by railways and steam boats, and with the facilities of international interchange of experience, invention, and scientific investigation, caused by these means of modern intercourse. International Exhibitions have also contributed not a little to give a cosmopolitan character to ore-dressing, as well as to other departments of mechanical art.

2. Expedients, Applications, Aims, Extent, and Scientific Condition of Mechanical Ore-Dressing.—Mechanical ore-dressing, especially in German text-books, is called the "wet-way," as distinguished from the "dry" operations depending on simple manual labour of sorting and breaking up the gangue, the picking out and the separation of the solid rich ores. Both operations are, as a rule, so connected, however, that the distinction is difficult to maintain. A purification by water, combined with a separation according to the size of the grains, forms the preparation of the fine stuff for hand-picking and sorting. But in later times a previous mechanical breaking into handy pieces, together with the purification and separation, according to the size of the grains, is customary, even with coarse material. However, other aids have been employed besides the effect of water in mechanical ore-dressing, viz., that of air. Even magnetism has been used with success in isolated cases. In this examination the special circumstances which necessitate manual labour previously or intermediately to mechanical operations cannot be gone into in detail. Hand and eye remain for certain labour, as a rule, the simplest and cheapest means, even with low-priced minerals, like anthracite coal and iron ore; and the richer and more valuable the ores to be prepared, the more indispensable they become, especially with rich silver ores, whose softness, and the ease with which they are flattened into the finest scales, in the slime process in water, cause the most serious loss. With the ores of the noble metals—gold and silver—the metallurgical processes, amalgamation and chlorination, are for the most part connected directly with the comminuting processes. These operations will not be entered into here. The specifically lighter foreign substances, quartz, lime, and heavy spar, iron ore, pyrites, zinc, and blende, are to be separated from ores by mechanical dressing; while from anthracite are to be separated partly the specifically lighter so-called lignite, partly the specifically heavier slate and iron pyrites.

Mechanical dressing is also made use of where rock-salt occurs with the salts of other alkalies and alkaloids, as at Stassfurt. The method essentially depends partly on the character of the ore, partly on local circumstances. In case of silver-bearing lead ores, the separation of the often associated zinc-blende is an essential requisite to the prevention of a loss of silver and to the obtaining of a good action in the furnace during the smelting process. The removal of the silicious gangue, as a rule, is more important than that of lime, iron pyrites, brown and spathic iron ore, because usually in smelting silica is present in excess, and therefore must be removed to form a slag; but iron serves as a protection against the slagging of the more precious metals. The most important influence upon the employment of mechanical ore-dressing is exerted by the condition of transportation between the mines and the smelting works, and afterwards, too, from the smelting-works to the metal market; by the proximity of fuel for working the ore-dressing machines and smelting-furnaces; by a supply of water at hand for the slime apparatus; but most especially by the rate of wages. The great expense of transportation or of selling frequently stands in the way of using the best and most efficient machines, and a more complete concentration of the ore is unadvisable, particularly in the working of finely divided ore masses, which must be subjected to the especially difficult slime process, on account of the loss of ore, which increases greatly in proportion to the degree of concentration. The chief objection to mechanical ore-dressing by means of water is the loss of ore, and this objection demands the most mature reflection and consideration

of the combined economical conditions of manufacture and trade. The complicated contrivances and methods of work arising from the struggle for improvement are less permanently enduring in mining than in any other branch of industry, and therefore are, as a rule, replaced by the most durable machines and simplest operations possible. The dressing is limited in the case of cheap iron ores to mere washing or removal of the mass of clay in which brown iron ore frequently occurs. With stone-coal it consists merely of a separation into various commercial lots, according to size, or, as with the Pennsylvania anthracite, of washing, united with a sufficient breaking up to suit the demands and customs of consumers, while stone-coal for coking requires a cleaning from the foreign ingredients, slate, iron pyrites, &c., in order to produce a coke with as little ash as possible, as demanded for smelting. The production of artificial fuel (briquettes) is closely connected with the mechanical dressing of coal. Mechanical dressing, besides the proper sizing of the ore or coal, effects the separation of the smaller grains according to the specific gravities of the combined minerals. It is therefore an apparently simple process based on the laws of pure mathematical physics. We merely mention the well-known and scientifically established laws of the free fall of bodies in a fluid medium—water or air—the rolling or sliding friction on smooth planes more or less inclined, impulsion, adhesion, centrifugal force. The dissimilar form of the comminuted pieces, according to the character of the minerals, but especially the minimum action and very small size arising from the fineness of the grains in sandy and slimy masses, exert such serious and incalculable influence everywhere, that exact theoretical investigations and physical experiments meet with peculiar difficulties in the department of ore-dressing. In the beginning empiricism has, therefore, here, as in most other branches of technical knowledge, preceded the theoretical perception of phenomena. But theory, though it has since clearly demonstrated the law, has not yet obtained sufficient credit in practical affairs to solve technically the delicate questions of the art of ore-dressing.

II. The Development of Scientific Principles.

1. General Principles of the Wet-Way.—The works on mechanical ore-dressing in the first half of the century here to be considered have confined themselves, as a rule, merely to the description of arrangements and manipulations in use in certain mining districts, and the practical experience acquired therein. Dr. T. C. B. Karsten first gave a general scientific description of ore-dressing, and a critical elucidation of the methods of work known and in use at that time, with his observations thereon, in his *System of Metallurgy*, published in two volumes in 1831.*

An interval of twenty years elapsed, viz., till the year 1851, before the method of careful observation in the path of analytical experiments, to which we owe the great advance of the present day in the department of science and in all branches of industry, was applied to the well-known phenomena of mechanical ore-dressing. M. V. Pernolet published at that time the results of his comprehensive experiments† on the free fall of bodies of different specific gravities in mediums of different densities—water, brine, and solutions of sulphate of iron—not only in the quiescent state of the latter, but also in horizontal streams of water and air.

At the same time he particularly directed his attention to the limits within which it is possible to sort, mechanically, comminuted ore and gangue, through sieves of certain mesh, by volume and by size of grain, before the separation by specific gravity. He further determined the influences caused by change in form of the fragments, experimenting first with the ball as the simplest figure, and then with cubes, plates, and wedge-shaped splinters. He also analyzed the sharpness of separation according to specific gravity, the

* In this well-known work (p. 379) a review is given of the then existing literature of ore-dressing, to which we here refer; with regard to the new literature, consult the text-book of Prof. M. A. Gätzschmann, vol. i., 1864; vol. ii., 1872; published at Leipsic, by A. Felix.

† *Introduction à l'Etude des Préparations méchaniques*, *Annales des Mines*, 4 sec. sér., 1851, tome xx. pp. 379 and 535; 5 sér., 1853, tome iv. p. 144; 1856, tome ix. p. 281.

mineral character of the constituent parts taken into consideration. Pernolet proved at the same time that water, by reason of its greater density, furnished a more fitting medium than air for separating the comminuted ore and gangue by free-fall, according to the specific gravities, and rejected the system of wind separation proposed by Grand-Besançon in the year 1828, which, some twenty-five years later, under the name "trieur à vent," was tried in the mines of Nouvelle Montagne, near Engis, in Belgium, and in other continental mines (among others, also, for dressing rock-salt at Stassfurt), without proving permanently practicable in the direction pursued at that time. He further made various proposals to try the separation in a deep trench of water, through the combined effect of a free-fall of the grains to be separated and the velocity of the stream of water.

The two German mining engineers, Chief Director of Mines Julius von Sparre and Mining Assessor Max von dem Borne, may be called the founders of the modern theory of ore-dressing, through their scientific investigations of the mathematical laws upon which the separation of minerals of various sizes, both in still water and in moving streams of water, even to the finest slimes, depends. They, especially the first mentioned, have succeeded in developing general formulæ, by the introduction of simplified hypotheses, which, within certain limits, can be used even in the most complicated cases of practice, and which later co-workers on the same subject have not replaced by more practical methods of mathematical solution. That the merits of these worthy gentlemen, richly deserved by the introduction of several new and important apparatus for the dressing of ores practically, have scarcely been appreciated in technical literature ought not to be considered a sufficient reason, from the standpoint of unpartisan criticism, why, in this description of the historical development of ore-dressing, an attempt should not be made to examine more closely the results of their labours in comparison with those of other authors of a wider-spread reputation, who have made use of these results. The practical and theoretical labours of Von Sparre began demonstrably at an earlier date than those publications of Pernolet* mentioned above. An essay delivered to the Prussian Minister of Commerce, Trade, and Public Works, in June 1854, has not been published. A series of essays followed this in the years 1858 and 1859, published in the *Bergwerks Freund*, and entitled *Contributions to the Science of Ore-Dressing*. A shorter critical review of the results of his labours, in comparison with those of other authors, was published ten years later in a special paper.†

About the year 1863, Von dem Borne invented and introduced into practice the so-called "Strom apparate" (slime separators), cylindrical and funnel-shaped vessels, in which the separation is effected by a perpendicularly-rising column of water of constant velocity, and which have been often used with success.

In his essay,‡ published in 1857, he not only describes these apparatus, but also develops the mathematical formulæ of the laws of motion of ore grains in such an ascending column of water, expressed in simple, easily-understood propositions, as follows: In the three following general equations§ for two different mineral grains the specific gravity or density is designated d and d_1,

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* Von Sparre received a Prussian patent in 1852 for a revolving apparatus (Drehpeter), to separate the ore grains by free-fall in water; followed later by his "Fallgraben," gravitation-pit, depending for effect on a direct horizontal stream of water, and similar to Pernolet's apparatus.

† *Von Sparre on the Theory of Separation, or Critical Remarks on Rittinger's Text-book of Ore-Dressing.* Oberhausen, A. Spaarmann, 1869.

Von Sparre here maintains his and Von dem Borne's scientific priority. Without going into Rittinger's own defence in the Austrian professional journals, it is here well established that Rittinger knew the earlier labours of these authors, and had adopted their theories of the free-fall of mineral balls in water, at rest or in motion, in certain cases without acknowledgment of their origin. His varying theories in other departments of ore dressing are worthless, because resting on improbable hypotheses.

‡ In the *Zeitschrift für das Berg-, Hütten- und Salinenwesen in dem Preussischen Staate.* Vol. IV., p. 224.

§ The general formulæ which Messrs. Von dem Borne and Von Sparre have established for ball-shaped bodies, in the quoted essays, cannot be entered here, but only the chief results be given, and for further particulars the essays themselves must be consulted.

the diameter by D and D_1, the absolute weight P and P_1, the constant velocity of the ascending stream sufficient to keep these bodies floating at the same height by V and V_1, and c is a constant co-efficient derived from the medium and the form of grains.

1. When the two grains obtain the same constant velocity in the same ascending stream:

$$\frac{D}{D_1} = \frac{d_1 - 1}{d - 1}; \text{ or } \frac{P}{P_1} = \frac{d}{d_1}\left(\frac{d_1 - 1}{d - 1}\right)^3.$$

2. For the ratio which must exist between the velocities of two ascending streams of water, in order that two bodies of the same size and similar form, having different specific gravities, may be kept afloat, so that the bodies neither rise nor fall:

$$\frac{V^2}{V_1^2} = \frac{d - 1}{d_1 - 1}; \text{ or } \frac{V}{V_1} = \frac{\sqrt{d - 1}}{\sqrt{d_1 - 1}}.$$

3. For two bodies of equal specific gravities, but unequal diameters, under analogous circumstances:

$$\frac{D}{D_1} = \frac{V^2}{V_1^2}; \text{ and } V = \sqrt{c\frac{d - 1}{D}}.$$

The three different formulæ are only true for the maximum velocities obtained for the free-fall of balls in water, and must be used only in separations effected by a fall through a very large uninterrupted space. With these limitations, the following rules obtained by Von dem Borne are true:

A.—A body introduced into an ascending stream of water of constant velocity obtains, in a certain, comparatively very short time, a constant ascending or descending velocity; moreover, the less its diameter and the less its specific gravity exceeds that of the water, the greater is its velocity.

B.—Of two bodies of different specific gravities, which are moved by an ascending stream of water of constant velocity, and whose diameters are such that they both in time obtain the same velocity, the specifically lighter of these equal-falling bodies moves, in the beginning, faster than the specifically heavier one.

C.—The formulæ Nos. 1 and 2 are independent of the greatness of water-velocity V; therefore must two equally-falling bodies obtain the same velocity of motion in every ascending stream of water of constant velocity, whether it moves quicker, slower, or not at all. The formulæ and the above two laws are, therefore, true for the free-fall of bodies in water at rest. Von Sparre, in his *Contributions to the Science of Ore-Dressing* (p. 375), developed from formula No. 1, under this hypothesis, the law of equal-falling balls.

D.—Where equal spaces are fallen through in the same time, the diameters are in inverse ratio to the specific gravities, the weight of the water being deducted. Further, in regard to the extent of space passed over at the maximum velocity, this author has proved the additional law:

E.—Balls of equal specific gravities, which fall through equal spaces in the same time, are to each other as the square-roots of their diameters; if of equal diameters, they are to each other as the square-root of their specific gravities, the water being deducted. Finally, Von Sparre proved (p. 338) the important rule:

F.—If the same kind of separation is to be produced between balls of different specific gravities, passing through a given space with the maximum velocity, then must the greatest and smallest diameters of the grains contained in the mass to be worked up always stand in the same geometrical ratio. This proposition is especially important in practice, because further rules are founded on it.

G.—In sorting according to the size of the grains, by means of a series of sieves of different meshes, which should precede the separation by specific gravity, the diameter of the successive meshes should diminish in geometrical progression. These simple principles afford a sufficiently safe basis for a pretty broad field of operations. We compile in the following tables the theoretical values of the principal minerals treated in dressing, figured from

the above and from Von Sparre's formulæ, with Pernolet's experimental results, in Tables 3 and 4, farther on, which are adapted to the circumstances of practical business, and show the influence caused by the form and structure of the minerals.

TABLE I.—*Theoretical height of fall of ball-shaped minerals, in equal falling-times, in water, at rest, according to Von Sparre.**

Diameter of Ball in Millimetres, corresponding to the Falling Time of		Height of Fall in Equal Times in Millimetres.				
3·600 Seconds.	17·125 Seconds.	Gold.	Galena.	Blende.	Quartz.	Anthracite.
a. 17·432	0·7714	9416	5658	3844	2807	1216
b. 8·716	0·3857	6658	4000	2718	1985	859

The ratio of the diameters of the balls for the shorter falling-time in column 1, as well as for the longer falling-time in column 2 of the two lines *a* and *b*, is as 1 : 2. This geometrical ratio of ball-diameter requires the same ratio of falling-heights in equal time. If the columns 1 and 2 designate two sorts of grains, classed by sieve, and the diameters at *a* and *b* represent the largest and smallest grains of the two kinds, then is the ratio 2 : 1 of the maximum to the minimum not yet sufficient to separate blende from quartz by means of free-fall. In consideration of this circumstance, and of the influence of the grains of mineral to be separated, Von Sparre has adopted the geometrical ratio of $\sqrt{2} : 1$, for the diminution in the size of the mesh of the sorting sieves or drums for practical use, and has reckoned out the following table, No. 2, metrically from that formula :

TABLE II.—*Theoretical maximum falling-velocity of sorted mineral balls in standing water, by Von Sparre.*

Kinds of Grains.	Diameter in Millimetres.	Space fallen through in One Second in Millimetres.				
		Gold.	Galena.	Blende.	Quartz.	Coal.
	17·44	2615	1572	1068	780	338
2	12·31	2200	1322	898	656	284
3	8·72	1849	1111	755	552	239
4	6·16	1555	933	635	464	201
5	4·36	1308	786	534	390	169
6	3·08	1100	661	449	328	142
7	2·18	924	555	377	276	120
8	1·54	778	466	317	232	100
9	1·09	654	393	267	195	84
10	0·77	550	330	224	164	71
11	0·54	462	278	189	138	60
12	0·38	389	233	159	116	50
13	0·27	327	196	133	98	42

* *Contributions to the Science of Ore-Dressing*, in the *Bergwerks Freund* of 1859, p. 387. The specific weight of gold is here assumed at 19, that of galena at 7·5, of blende at 4·0, quartz at 2·6, and of anthracite at 1·4.

TABLE III.—*Medium falling-velocity of sorted mineral grains in a standing column of water, according to the experiments of M. Pernolet.*

	Diameter of Mesh		Falling Velocity in Millimetres per Second.						
	Through which the Grains have fallen.	On which the Grains were precipitated.	Galena.	Pyrites.	Blende.	Heavy Spar.	Calc Spar.	Quartz.	Coal.
	Millimetres.								
a	Square Sieve Holes								
1	30	18	1304–1013	—	—	—	—	645–263	270–164
2	18	7	1111–723	—	—	—	—	476–221	191–131
3	7	5·5	715–625	—	—	—	—	335–133	143–68
4	5·5	4·44	610–491	—	—	—	—	282–81	99–52
b	Round Sieve Holes								
5	4·44	4·17	667–389	445–353	439–295	409–316	322–217	282–91	80–60
6	3·94	3·67	480–344	360–245	316–166	343–220	265–136	231–92	92–41
7	2·77	2·50	386–275	295–185	237–111	280–131	200–115	200–51	76–28
8	1·77	1·50	325–193	164–158	144–79	191–85	162–71	132–80	49–19
9	1·50	Cambric	273–145	200–64	161–58	152–62	107–40	115–48	—
10	Cambric silk gauze		128–49	240–116	—	92–48	61–23	49–26	—
11	Dust fallen through silk gauze.		89–25	—	—	97–41	54–21	—	—

From the coarser grains in the above table, that is, the first four sieve-classes, M. Pernolet has also determined for each sieve-class and each mineral the proper weight for the greatest and smallest grains of each class, corresponding to the maximum and minimum velocities given in the table.

TABLE IV.—*Maximum and minimum gravities of the grains of the classes* 1–4 *inclusive of Table III., by Pernolet.*

Class of Sieves.	Galena.		Quartz.		Coal.	
	Maximum Grains.	Minimum Grains.	Maximum Grains.	Minimum Grains.	Maximum Grains.	Minimum Grains.
1	78·33	17·50	44·20	2·70	18·00	3·75
2	21·25	1·43	10·70	0·214	5·00	0·333
3	1·416	0·040	0·90	0·086	0·225	0·050
4	0·600	0·120	0·30	0·032	0·150	0·020

If we compare the grains of the three minerals, galena, quartz, coal, assumed in the table to be of equal value, with the maximum and also with the minimum size of each class of sieves, we obtain the following observed ratios of the medium falling-velocities of such equal-sized kinds of grains:

	Maximum Grains.	Minimum Grains.
Sieve-class 1	4·83 : 2·40 : 1	6·18 : 1·60 : 1
„ 2	5·82 : 2·50 : 1	5·82 : 1·70 : 1
„ 3	5·00 : 2·70 : 1	9·20 : 1·96 : 1
„ 4	6·16 : 2·85 : 1	9·46 : 1·55 : 1
Average value =	5·45 : 2·61 : 1	7·59 : 1·70 : 1

According to Table II. the relative velocity of these ball-shaped bodies must be in the ratio of $1572 : 780 : 338 = 4{\cdot}65 : 2{\cdot}31 : 1$.

While, accordingly, only a slight variation, due to form, shows itself for the maximum grains of the first class, a considerable irregularity, increasing with the fineness of the grains, appears in the finer, especially the minimum class. The quartz grains of the first sieve-class appear to fall nearly the same as the galena grains of the fourth class. The size of mesh gives a ratio of about 5 : 1. Table II., column 4, shows, for approximately equal-falling grains of quartz and galena, a diameter ratio of $17{\cdot}44 : 4{\cdot}36 = 4 : 1$. The coal grains of Pernolet's first sieve-class appear almost exactly equal-falling with the galena grains of the ninth sieve-class, the ratio of the mesh being $30 : 1{\cdot}5 = 15 : 1$. According to Table II. the theoretical ratio of diameter of equal-falling grains of coal and galena in $17{\cdot}44 : 0{\cdot}77 = 23 : 1$. There still remains to be considered, that in these experiments the coal grains of the first class have been sorted with square-holed sieves, and the galena grains of the ninth class with round-holed sieves, and that the true ratio of the diameter of equal-falling grains might be larger than 15 : 1, perhaps 20 : 1. In this experiment there appears as great an agreement with the above theory as can generally be expected, considering the irregularities in practical grain-sorting. Table III., up to the ninth sieve-class, which includes grains from about 4·5 to 1·5 millimetres in diameter, shows tolerably distinct gradations in the falling-velocity from sieve-class to sieve-class. In the two finest classes we find irregular appearances from the impossibility of sorting such fine sand and dust, according to size, through sieves. Experience has since shown that these nine sieve-classes form the practical limit to which the drum-sifting and jigging of our newest and best ore-dressing establishments can go. Below these limits the slime processes begin, in which technics must still expect to have to solve the worst difficulties. Before we enter upon the complicated arrangements of slime-dressing we may be allowed to dwell somewhat longer on the principles of the dressing of the coarser material, the granular and coarsely-crushed stuff. The apparatus used for the preparation of these sorts of stuff in the wet-way can be divided into the following groups:

1. Gravitation Apparatus, for separation, in still or horizontally-moving water, by which all the grains are deposited in several successive layers on the bottom, or caught in several adjoining compartments, and separated into the various kinds of minerals by specific gravity.

2. Slime Separators, cylindrical or funnel-shaped vessels, in which a perpendicular-rising stream of water carries up the lighter and finer grains, but allows the coarser grains to sink down, and consequently divides into two kinds only.

3. Jiggers, or Jigging-Machines, in which the water works from below, with intermittent upward thurst, against sieves, upon which the matter to be separated lies spread out flat, and is raised by the shock only a few centimetres to fall directly upon the bottom again, so that the separation of the minerals into various layers according to specific gravity occurs only after repeated rises and falls.

The *first group* comprises the settling-pits, the cylindrical setting-tubs of Von Sparre, Hundt, and Rittinger, and the coal-washer of Evrard. This group, after a previous careful sizing by means of the preceding principles, gives a sufficiently close separation according to specific gravity, but still only reaching the size of fine grains. But since, in falling, the heavier grains knock against the slower and lighter ones and drive them from their course, and since practical difficulties are connected with the introduction of the grains into the water and the maintaining of a uniform motion of the water-stream, the permanent introduction of these apparatus into practice has been delayed or rendered difficult. According to the experiments of Pernolet and Von Sparre, these objections are especially true in working fine matter. The same phenomena, according to Pernolet, appeared in using streams of air, only in a higher degree, and even failure occurred.

The *second group* comprises the cylindrical, siphon, and funnel-shaped apparatus, the so-called slime separator or siphon apparatus and sluices. This is adapted to the separation into equal-falling sorts of sandy ores which cannot be further sized on sieves. Finished dressing products cannot be made of sufficient purity, as a rule, by this method unless the material has had special treatment beforehand in another dressing apparatus, operated on a different principle from that of equal-falling grains.

The *third group*, which includes the variously constructed and especially important jiggers, does not absolutely demand an earlier or later careful sorting of the grains in order to produce sufficiently pure products and tailings, but the labour of separation is shortened and lightened by it. It is adapted to coarse stuff as well as to sand.*

The principle of equal-falling grains does not apply to it. As we have already above discussed the principles by which equal-falling grains are separated in a rising column of water of constant velocity, and have besides seen that they are applicable to a still column of water, the principles applicable to the third group, viz., the jigging-machines, remains to be developed in a rapid manner.

Jigging Operations.—Von dem Borne has already shown, in his above-mentioned law, B, that equal-falling bodies,—*i.e.*, such grains of different specific gravities as attain the same constant velocity in a rising stream of water after the lapse of a given interval of time,—the specifically lighter bodies must fall, in the beginning of this time, quicker than the specifically heavier ones. Now, as in all jiggers a repeated up-and-down motion takes place in very short intervals of time and with a very small rise and fall, and since, at the same time, the ascent of the jigging stuff must take place by jerks, but the descent by the most undisturbed free-fall possible, in order to produce an effective separation, no use must be made here of the principles of and observations upon the average falling-velocity of equal-falling grains with a constant maximum velocity, which are true, though for a longer interval of time of fall, and may be considered as synonymous in practice.† In these rapid oscillations between a higher and lower point of rest, the essential question is the repeated effect of the falling-velocity, variable in the beginning, of mineral grains within very small heights and times of fall. The influence of the push raising the mass on the sieve is, however, entirely left out of the calculation. The merit of having cleared up and proved theoretically, as far as possible, this difficult problem of jigging, so extremely important in practice, is due to Von Sparre. As the complication of the formulæ developed by him in his *Contributions to the Science of Ore-Dressing* forbids their direct use, he has there made a table (page 401) which shows clearly the initial and still increasing velocity of, and the space fallen through by, galena and quartz balls of different sizes, as well as the resulting differences of the spaces fallen through in different fractions of the first second. In this way is shown, in figures, the law according to which the differences of the spaces fallen through in the same time by balls of varying size and specific gravities increase. We here, in Table V., give an extract from it. Two sorts of grains of galena are placed therein, together with two relatively equal-falling sorts of quartz grains, and also with a third quicker falling and very coarse sort of quartz grain, in order to show that on the jigger the finest grains of galena can be separated from the coarse quartz grains by means of a very low height of fall, not exceeding ten millimetres.

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* According to Karsten, p. 347, cobalt slich, from the percussion table process, containing spathic iron ore, had been successfully cleaned from the foliated spathic iron-sand upon horse-hair jiggers fifty years ago, in Siegerland.

† The more general definition of the jigging-machine, given by P. von Rittinger (*Lehrbuch der Aufbereitungskunde*, Berlin, 1867, p. 273), which is said to include the three groups above, is opposed to the theory and generally introduced customs of speech on ore-dressing science.

TABLE V.—*Initial falling-velocity and falling-height of galena and quartz balls, by Von Sparre.**

Falling Time in Seconds.	Falling Velocity in Millimetres.					Total Height fallen through in Millimetres.				
	Galena.		Quartz.			Galena.		Quartz.		
	Diameter of Ball.		Diameter of Ball.			Diameter of Ball.		Diameter of Ball.		
	0·5 mm.	2·18 mm.	2·18 mm.	9·45 mm.	18·90 mm.	0·5 mm.	2·18 mm.	2·18 mm.	9·45 mm.	18·90 mm.
$\frac{1}{10}$	101	105	72	73	73	0·65	0·66	0·45	0·46	0·46
$\frac{2}{10}$	177	203	134	144	145	2·42	2·49	1·75	1·82	1·82
$\frac{3}{10}$	245	358	214	270	281	7·88	9·95	6·21	6·88	7·19
$\frac{4}{10}$	236	506	261	436	499	20·9	32·1	18·4	25·2	27·0
$\frac{5}{10}$	267	553	267	540	711	47·1	86·0	45·0	75·5	89·6
$\frac{6}{10}$	267	555	267	554	742	74·3	141·5	71·7	130·4	164·2
$\frac{7}{10}$	267	556	267	555	782	101·0	197·1	96·0	185·9	242·0
$\frac{8}{10}$	267	556	267	556	785	127·7	252·6	125·1	241·4	320·2
$\frac{9}{10}$	267	556	267	556	786	154·4	308·3	151·8	297·0	399·0

The above table shows clearly that the separation, even with high-rising jiggers, for very coarse-grained stuff depends upon the cumulated effects of very small spaces of time, of less than $\frac{1}{10}$ of a second, and that it only needed a diminution of the height of lift of 2·5 millimetres, and of the falling-time of $\frac{1}{40}$ of a second, in order to separate very small galena balls with a diameter of ½ millimetre from 38 times thicker quartz balls of 18·9 millimetres diameter.†

A further separation, through specific weight on jiggers, can still be undertaken with success, though the material has been previously sorted by free-fall in standing or moving water, or in a slime separator. According to the theoretical principles of Von Sparre, the previous sorting of the mass, according to size of grains in the jigging process, affords the advantage of a quicker and closer separation, according to specific gravity. With sorted grains, not only a greater efficacy of separation can be produced with the jigger at each lift, but it is also possible to give the requisite height and rapidity of lift to the jigger used for each kind of grain, or, in other words, to separate the coarser grains, with stronger stroke and slower change of lift, from the finer grains, with weaker stroke and quicker change of lift. The question whether in a given case it is more advantageous to go into the minute and costly grain-sorting by means of screens or drum-sieves, or to carry on the jigging operations without sorting, and with the simplest possible machinery, after the old English custom, is to be decided solely by the economical considerations which have to be taken into account in regard to the plant of an ore-dressing establishment, as well as the rate of wages and the loss in dressing. Where it is difficult to set up and maintain machinery, and labour is cheap, with only a small quantity of mineral to work, or with minerals of little value, the preference is to be given to the English hand-jigging, more especially as by this practice a sorting according to the size of grains, though incomplete, takes place during the jigging process. In the English practice jiggers are used of the widest possible mesh, made of thin-woven iron wire, which are suspended in a roomy water-cask. The width of the machine-opening is about one centimetre. The practice is to gradually concentrate the material containing ore by repeated operations, to diminish the loss by dressing, and at the first operation to get rid of as much as possible of the refuse "deads," so that, in the following operations of jigging, only a comparatively small

* The figures of Von Sparre's table are in old Rhenish inches, carried out to 5 decimal places. In the above reckoning a less number of places has been adopted as more clear and sufficiently accurate.

† In the English jigging process and in Evrard's cylindrical jigger the separation of stuff not previously sized depends on a very low lift.

quantity, which can be more carefully treated, remains to be worked up. Then can ores difficult of separation—galena, blende, pyrites—be obtained separately with moderate closeness. The means used for this purpose, jigging into a lower vessel and upon a selected ore-bed, are deserving of notice, not only on account of the English hand-jigging practice, but are rendered conspicuous for the reason that they have been used of late for the separation of sorted material on continuous jiggers, for the removal of the specifically heavier ore grains, with most favourable results, and also in a system of three or four jiggers in a row, upon which the jigging-stuff carried forward through the stream of water, so as to separate it from the barren stuff, the "deads" (which remain in the bed until the end), by means of the specific gravities of the kinds of ore chosen for the bed, as follows: 1, galena; 2, blende; 3, pyrites: or 1, galena; 2, broken or crushed stuff (Schurerz, Walzerz) coarsely disseminated with ore; 3, pulp from the stamps (Pocherz) finely disseminated with ore, the middlings from the dead and country rock, "deads," remaining till the last on the bed. The difference between those old and these new practices is that a sufficient number of ores in the continuous jigger are separated in one operation on several sieves, while in the other the same material must be passed many times through the same sieve. In the English hand-jigging operation, the first jigging, especially with poor stuff, takes plece without an ore-bed. The unsized stuff is brought on to the previously emptied sieve, and worked up with rapid and gentle concussion, so that the finer grains, still containing ore, fall through the sieve with the fine ore slich. Fine and coarse grains of dead stuff remain in the uppermost layer on the sieve, which must be removed as refuse at each stopping of the jigging. The richer layer underneath is renewed in strata, and the medium layer is further treated as middlings, stamp-stuff, and crushing stuff, while the lowest and richest granular layer is put aside in bulk for later fine jigging, as it heaps up on the sieve and interferes with the falling through of the finer grains, which still contain ore of the average specific weight of broken galena or poor blende. As soon as the lower tub is filled with the finer ore-stuff, considerably concentrated by the first operation, the water with the slich suspended therein is drawn off from this receptacle into the labrynth and into the sump, the remainder turned out, and then subjected to the second operation. If galena mixed with blende or pyrites occurs, an additional thin layer of blende or pyrites grains of the right size is in the next place spread out on the sieve, and over it is placed the material to be jigged. In the shocks of the jig which follow, the "bed," forming the lowest layer, permits only the specifically heavier grains, that is, of galena, or of blende interspersed with galena, to pass through the sieve into the lower tub; on the contrary, all grains of equal specific gravity, such as blende, blende grains, and the galena grains, closely united with gangue, remain lying on the blende-bed, which is impenetrable for them. Over the fine grains of blende lie in close proximity the stuffs for rolling and stamping. These are taken off from the layer of fine blende grains underneath, and then this last layer is obtained as a finished product on the bed.

The third operation upon the concentrated galena-stuff, which has passed into the lower tub, is then begun on a bed composed of pure gelena grains, by which means the pure galena settles into the lower tub, and over the bed is spread a fine middle stuff, galena containing blende. The skill of the jig-workers is shown in forming the ore-bed. It is evident that the success of the work is easily endangered where the frequent renewals and changes needed are carried out with deficient skill or experience. On this ground, too, the hand-jigger gives less equally-separated sorts of ore than the continuous-acting jigger, over which the overseer can have a systematic control of the condition of the ore-bed.

In forming ore-beds, not only is the specific gravity, but also, especially with the coarser ore grains, the form of the bodies making the bed to be considered; since galena grains rapidly become round by friction and then unite so closely, even during the motion of the sieve, that the smaller galena grains cannot penetrate from above into the intervals, and so remain above instead of entering the lower tub; for this reason they have used lately in Upper Silesia, with great success, in the continuous jigger, instead of galena grains, fragments of old iron, short bolts, rivet-heads, nuts, of the requisite

size.* In ore-dressing, of late years, an increasing preference has been shown for the more complete practice of working up only carefully-sized material on the continuous jigger. On the contrary, it has been found that in coal-dressing it is not expedient to classify the jigging stuff any further, according to size of grain, after separation of the coarser pieces still suitable for hand-picking, and after washing off the finest coal-dust. The low specific gravity of coal facilitates the separation by jigging so much that even the finer pieces of slate and iron pyrites fall to the bottom quickly enough. Besides, a mixed material of various kinds of grains can be raised on the sieve by water impact higher, and therefore can be worked up more easily and quickly than if the coarser grains were jigged by themselves. While, earlier in the theoretical struggle after improvement, the classification according to the size of grains, even in coal-washing, has gone much too far, leading to the setting up of complicated machinery; still, the advantage, which every simplification of method in conformity with principles affords, finds due consideration in the later establishments, even where the most complete apparatus is in use.

Slime Process on Tables.—The dressing of the very fine sandy and slimy ore-stuff, which is no longer suitable for jigging, is still in a rather unsatisfactory state of development.

Even here must a sorting, according to size of grains,—"sizing,"—precede the cleansing according to specific gravity,—"separating."

This previous work is no longer practicable by means of sieves, on account of the small size of the sand- and dust-particles. In the last century, a system of slightly-inclined or horizontal troughs, the labyrinth (Mehlführung), with gradually-widened cross-section, through which the sand and slime particles suspended in water, the "trübe," were conducted with decreasing velocity, in order to deposit these particles, and, after sorting them incompletely into fine and coarse sand and slime, of various grades of fineness (Zähigkeit), to obtain a supply for further working up. As the heavier, finer ore-particles are deposited at the same time with the lighter, coarser particles of refuse, therefore, as a rule, concentration according to specific gravity takes place by this treatment in such a way that the deposits in the current of the troughs become successively poorer; so that, if the last trough or sump is made wide and deep enough, the last and finest tailings can be allowed to escape unused, as surplus water, being too poor to pay for further dressing.

The wide extent of surface, and especially the troublesome and expensive removing, collecting, and transporting of these different varieties of sand and slime, has, during the last fifty years, prompted many improvements for taking the place of the labyrinth, especially for the purpose of withdrawing from the principal stream the sized and relatively enriched kinds of sand and slime in concentrated form, and to conduct them directly, and still held in suspension in water, to the apparatus which further concentrates them. After Schitko, in Schemnitz, in 1823, had made use of the principle of an ascending stream of water in his trough apparatus (Luttenapparat) without success, Von dem Borne, about 1853, introduced this principle into practice, in his cylindrical slime separator, and even Rittinger succeeded in giving to that apparatus a practical form, in the inclined rising and falling wooden trough of his "Spitzlutte." Rittinger further succeeded, by the use of long pyramidal vessels, with point or edge turned down, in making the so-called pointed box (Spitzkasten) a very efficient apparatus for sorting and precipitating slimes, which since its first use in 1844, at Schemnitz, has been in general use. Wimmer, at Clausthal, soon after 1850, discovered his pointed separating tubs (Spitzgerinne), used in separating the sandy material coming from the labyrinth, composed of two side walls, with an outlet in the deepest part of the troughs. In this apparatus the principle of free-fall in a horizontal stream of water, with a gradually diminishing velocity, is made use of. C. Kley and Bilharz, some few years later, discovered and improved, at the Altenberg Mine, near Aix-la-Chapelle, the "Stromgerinne," a more perfect

* In washing coal at Waldenburg, in Lower Silesia, feldspar grains are used with advantage for the bed of the jigger.

form of pointed trough, by which a clear stream of water is introduced from below, through a slit in the trough, in order to free the coarser sand grains, that sink out of the tailings from the finer sand and slime particles. With this principle, also, was combined the principle of an ascending stream of clear water, which Hoffmann had made use of ten years before in Banat, in his slime separator (purifying-tubs, Laüterkasten), and which has been carried out later, systematically, by Von dem Borne. Martin Neuerburg,* civil engineer at Kalk, near Cologne, well known through his exertions in the field of ore-dressing, produced an apparatus under the name of "Classificator," which worked with similar effect, but which outwardly was more nearly related to Von Sparre's settling-pit.

This combined treatment then came into use, for the tough slime, in pointed boxes. The previously-developed laws of free-fall in water, which, according to Pernolet's experiments, do not hold true with the finest sorts of grains, that can still be easily measured, can be used in the previous apparatus only to a narrow extent; because the influence of the adhesion of the water increases to such an extent, with the fineness of the grains, that the influence of gravity on the single grains is nearly destroyed, and the mass of slime assumes the peculiarities of gelatinous substances. This condition is especially produced by the limy and slaty-clay refuse, which is closely connected with the ores, and renders extremely difficult the further treatment of the slimes by washing. According to the theoretical development of Von Sparre, in the above-given discussion upon the rolling friction of grains upon a smooth horizontal surface, the grains deposited in the old labyrinth, with a certain velocity of water, would be in diameter inversely as the squares of their specific gravities, the weight of the water being deducted; but with equal specific gravities and decreasing velocity, the diameters of the grains deposited in the stream are to each other as the fourth powers of the velocities of the stream. This law differs essentially from the above-mentioned laws of equal-falling grains, as proved in the slime separator, whose diameters were inversely as their specific gravities, the weight of the water being deducted. In the case of the sluices and pointed boxes, where the rolling friction and the stream of water act in combination, even without considering the influence of adhesion, a complication of both laws must necessarily occur. The theoretical examination of the foregoing laws proves still more difficult in washing out finer material on either fixed or moveable inclined planes.

Von Sparre's theoretical investigations in this department, which are to be preferred to those of Rittinger, in our opinion, have prepared the way to clearing up and making easily understood, in some measure, the peculiar phenomena of washing operations. It would, however, be going beyond the limits of this essay to enter in detail into the numerous propositions developed by Von Sparre. We must, therefore, limit ourselves here to seizing some few principal points only.

In the year 1853, Von Sparre caused to be constructed an apparatus which is very suitable for ore-dressing experiments in the laboratory, and which permits the velocity of the stream of water to be regulated independently of the inclination of the table surface.†

The experiments with it, in conformity with theoretical investigations, undertaken under the supposition that it is possible *to regulate the velocity of water independently of the inclination of the table surface*, gave the additional rules:

H.—With grains of a given specific gravity, every angle of inclination of the table surfaces is suited, or adapted, to a distinct size of grain, which opposes the greatest resistance to the stream of water, and, by a gradual strengthening of the stream, is finally washed along.

I.—The larger the grains to be obtained the smaller must be the inclination of the table; on the contrary, the smaller the grains the greater must be the inclination.

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* Formerly technical director of the Humboldt Stock Company (previously Sievers & Co.) at Kalk.

† The apparatus, under the name of "Glass Inclination Table," may be ordered from the mechanician, Dr. Geissler, of Bonn, at the price of 9 marks current.

K.—A perfectly determined diameter corresponds to every given angle of inclination, which, for all grains of the same specific gravity, presents the greatest resistance to the current of water, and is equal for all substances independent of their specific gravities; therefore the velocity of water, by which grains of a given diameter are deposited, is as the square roots of the specific gravities, and the same is true for the velocity of water by which the equal maximum velocity is given to such grains.

L.—The separation goes on more easily, 1, the greater the difference of the specific gravity of the minerals to be separated and obtained; 2, the less the grains of the specifically heavier minerals to be obtained differ in size; and 3, the more the average size of grain of this mineral varies from the mineral to be obtained.

These requisites, according to Von Sparre's further experiments, are only attainable upon open tables to which a certain motion is communicated, and whose effect, together with the force of gravity acting on the water and on the grains, unites in an effective resultant force in an oblique direction, 1st, through a backward motion, as in the ordinary percussion-tables; 2d, through steadily operating centrifugal force, on buddles; 3d, through intermittent centrifugal force, on oscillating or horizontally shaken tables.*

The end- and side-stroke of the percussion-table,—which is supposed to have sprung up in Bohemia, from the old Saxon testing-tray (Sichertrog), and which was known in Hungary in 1770, was introduced into the Hartz Mountains in 1772, and was in general use in Austrian Hungary,—acts disadvantageously on the separation which the intermittent forward, rolling motion of the grains is said to produce. These apparatus are, therefore, from the theoretical stand-point, less advantageous than the tables working by centrifugal force, and are only to be considered as a make-shift till the requirements of theory are satisfied by the advance of technics in the making of suitable machinery. The above conditions cannot be fulfilled upon open, stationary tables, because the velocity of the water cannot be properly regulated, and because, to avoid too great velocity of water, especially for very fine material, much less inclination of table must be given than is suitable. The technics of dressing show, in all these apparatus, a highly-deficient separation, and the use of many minor processes which, as a rule, depend on the skill of the workman. The old German slime-pits and round buddles require the addition of a scraper (Kiste), while the sweeping-table, both stationary and rotating, conical and dished, needs brooms or brushes.

The plane-tables, which do extremely little work, depend on the retarding action of webbing or cloth, which wears out rapidly.

The English round buddle, invented in Cornwall, in 1842, by Hughes, or Ball, and likewise the funnel-shaped settling-tub, by Hundt, in Siegen, in 1857, in comparison with the German slime-pits, afford only the advantage of working up a greater mass at the expense of the machinery.

The same is true of the continually ascending and descending sweeping-table, whether constructed after the plan of the low, cone-shaped, rotating buddle, invented by Schell, in the Hartz Mountains, in 1853, or the low funnel-shaped one introduced by Neuerburg soon after, or resting on the principle that a broad endless cloth stretched between horizontal rollers to an inclined movcable surface is used for the table surface, as in the table introduced, in 1843, into Spain, and later into Cornwall, by the Englishman Brunton, with which the experiments of Hoffmann were made in a competitive trial at Banat, in 1844. The continuous removal of the "heads" on percussion-tables was attempted, in 1860, by Hartwig, at the Altenberg Mine, near Aix-la-Chapelle, by uniting it with Brunton's endless cloth, and by Rittinger, some years earlier, by means of a side thrust to the table; still, only Rittinger's continuous percussion-table, essentially altered by Palmer, in Olahlaposbanga, in Hungary, about 1860, has come into general use. The effect of centrifugal force in a rotating horizontal motion has been used from the earliest times down to the present day by gold-washers in the *pan* ("Washschüssel, Baten, Sebille"). After Schitko, in Schemnitz, towards the end of the twentieth year of this

* In the English Dolly-tub the centrifugal force is united with the loosening effect of heavy vibration in a deep cylindrical vessel; this has been long used with success to further concentrate impure ore slich, or to separate blende slich from galena slich.

century, and Von Sparre, in 1844, had recommended the use of concave, rotating, centrifugal buddles, Osann, in 1852, in the Hartz Mountains, and Hutzelmann, in 1855, in Przibram, made experiments therewith; but the former, after moderate success, was interrupted by conflagration, while the latter was unsuccessful. Experiments with Von Sparre's centrifugal buddle were made at Sangerhausen, in 1858. The buddle used had a funnel-shaped surface, inclined less than 45°, over which a narrow space was formed, by covering over with a reversed cone.* This covered table proved impracticable. Apart from the fact that the operations on the buddle could not be seen, the water, through the rapid rotation produced by the great inclination of the table, came directly on the buddle in such a heavy centrifugal stream as to prevent the separation of the grains. Von Sparre has therefore given up the system of covered centrifugal buddles, but recommends the use of open, concave, centrifugal buddles, with the table inclination and rotating velocity so calculated that the surface of the buddle may remain uncovered.

Hundt had constructed, in 1863, a centrifugal buddle furnished with a screw-shaped spiral surface wound around an upright rotating spindle, on which the centrifugal force should act in a contrary direction to the stream of water which descended in the spiral line. The apparatus has, however, obtained no practical importance. The shaking-table (Rüttelheerd), acting on Von Sparre's principle of vibratory, rotating motion, was developed about ten years ago, at the well-known Humboldt machine-shop (then Sievers & Co.), at Kalk, near Deutz, and is said to have given good results, even with slight differences of specific weight, without being introduced into practice, however. The same principle, though in a modified form of table, was employed by Ball, in 1856, at the Copper Falls Mine, on Lake Superior, without satisfactory results, for washing native copper, and by Boless, at Allenheads, Northumberland, for lead-ore dressing, instead of the "Dolly-tub." The foregoing principle of oscillatory, centrifugal motion, together with shocks, used in the oblong trough-shaped hand testing-pan, is represented in the washing at the Lake Superior copper mines, by small continuous percussion-tables, emptying at both ends; which the intelligent experts there are busily employed in perfecting. As the difficulties of the wet dressing of fine ores, till this time unsatisfactorily solved, increase greatly with the fineness of division, the principal task of the art of ore-dressing is to endeavour to produce as little as possible of the fine meal in reduction, and that where finely disseminated ore must be made fine, still the greater portion shall be only so far reduced as to be separated to the grain-size of sand, on jiggers, and so avoid the washing process on tables. In fact, the condition cannot be fulfilled with many ores disseminated with microscopical fineness, which must be dead stamped (Todtgepocht), and, therefore, generally prepared only with great loss.

III.—Krom's Principles of Pneumatic Jigging.†

The idea of using air as a medium for the separation of mineral grains, rejected in Europe as fruitless, was again taken up, in an entirely new direction, in the United States, by Mr. Stephen R. Krom, of New York, in 1868, and has since been systematically developed in exceedingly ingenious machines, which were an ornament to the Centennial Exhibition. This new treatment, only within a few years successfully introduced into some ore-dressing establishments, is yet too little known in its economical results to give a final judgment upon its possible advantages over ore-dressing in the wet-way; but it can even now be designated as a surprising advance

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* Compare the illustration in Von Sparre's contributions to the *Bergwerks Freund*, and Gätschmann's *Die Aufbereitung*, Table IX., Fig. 4.

† The author had an opportunity at the Centennial Exhibition of observing a Krom machine at work; he has, besides, based the following description on the oral explanations of Mr. Krom, and on his beautifully illustrated publication upon his system of ore-dressing (published by himself, office No. 206, Eldridge Street, New York). For this information he here expresses his gratitude. An extract from this publication, accompanied by working plans of a pneumatic ore-dresser, according to Krom's system, was published in the *Engineering and Mining Journal* of 1876, vol. xxii., page 284.

in the art of ore-dressing that the spirit of invention, even in this department, has so decidedly succeeded in producing unheard-of mechanical effects, in contradiction to prevailing theoretical opinions, that the correctness of the facts cannot be disputed.

The earlier experiments of air-separation were confined to velocity of a continuous stream of air produced by a ventilator in a high, horizontal, and narrow conductor (two to three metres square), through which the dried mineral grains introduced from above were separated in a manner entirely similar to that of the horizontal stream of water working in the settling-pit, according to the principle of free-fall. But Krom starts with the fundamental idea of compressing the air by means of a kind of piston, with quick, successive strokes, and, thus compressed, to let it work with great rapidity through a low stratum of mineral grains previously sorted according to size (sized), which rests on fine sieves inclosed laterally in a narrow space. Krom's pneumatic jig, or dry concentrator, is similar to the continuous hydraulic jig in outward appearance, and must be designated as an intermittent-working air-stream apparatus, in which, therefore, the dynamic effect of the living force produced by an upward jerk through the dense medium has a more energetic effect than by free-fall. In the employment of air in puffs as a medium its inferior density is a decided advantage. With water the *vis inertia* of the mass of the medium to be moved prevents driving a jigger at more than 60 or 120 strokes per minute, varying according to the height of stroke. Troublesome setting-back of the water takes place, which acts detrimentally to the separation on the sieve, to avoid which either the stroke and velocity must be diminished or a complicated arrangement be made use of. On the contrary, the air escapes at each stroke without set-back, and it is therefore possible to drive the pneumatic jigger at 420 to 500 strokes per minute,—consequently, very much more rapidly than the hydraulic one. Air is a medium to be obtained everywhere, while the procuring of the necessary water-supply is attended with difficulty, as a rule, and in many places is impossible. While the grains to be separated have to pass over a distance of about 1 or 2 metres on the continuous hydraulic jigger, they have to pass over only 13 centimetres of sieve-length on Krom's machine. This apparatus can, therefore, for the sake of concentrated efficiency, be more extended laterally without assuming troublesome proportions. As the adhesive effect of air, compared with water, is extremely small, it is evident that sands can be treated pneumatically which are very much finer than the finest treated on the hydraulic jigger. The dry sand forms a loose mass easily penetrated by the compressed air, while on the hydraulic jigger it is raised all together in a closely-adhering mass by the water-thrust, and, even in falling, hinders its own separation through mutual adhesion. While sands from 0·5 millimetre to 1 millimetre thick can scarcely be prepared on the hydraulic jigger, it is said that grains 0·01 millimetre thick can be separated pneumatically. In order to exclude the finer dust-particles, the mass to be separated is previously cleaned by blowing in a moderate current of air. Mr. Krom reports, in his publications, the striking results of comparative experiments which he made in two glass tubes, 2·44 metres long and 5 centimetres wide, each provided with a stop-cock underneath. He filled one with water and the other with a regulated stream of pressed air let in from below. In the next place he learned, by experiments with the glass tube filled with water, that a galena ball 3·2 millimetres in diameter and a quartz ball 12·7 millimetres in diameter fell through the column of water in the same time.*

Now, if the blast-valve in the air-tube is so regulated that the galena grain falls to the bottom just as rapidly as it did previously in the water-tube,

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* In our Table II., according to Von Sparre, in water at rest, the theoretical maximum velocity, when the ratio of the diameter is the same,—viz., 1 : 4,—is, for a galena ball (grain-size 6) 3·08 millimetres thick, 661 millimetres, and for a quartz ball 12·31 millimetres thick (grain-size 2) 656 millimetres. As in Table V., these maximum velocities were reached in the tube within the first $\frac{1}{10}$ of a second of the whole falling-time (3·7 seconds), which was more than twelve times as long, then the same values hold good for the medium velocities.

In Krom's experiments we find the fullest agreement with Von Sparre's formulæ and tables. Accurately calculated, the ratio of the diameters of equal-falling balls of galena and quartz would be $\frac{D}{D_1} = \frac{d_1 - 1}{d - 1} = \frac{2{\cdot}6 - 1}{7{\cdot}5 - 1} = \frac{1{\cdot}6}{6{\cdot}5} = \frac{1}{4{\cdot}06}$.

then can the quartz grain not be made to sink in this stream of air, but will be held in suspension by the stream in the upper end of the tube. Krom further found, by experiments with steel-wire tacks of 2 millimetres thickness of wire and 8 millimetres diameter of head, that a tack (*a*) 18 millimetres long, which was dropped into the water-tube at the same time as a shorter tack (*b*), 15 millimetres long, was in advance (only about 25 centimetres) on reaching the lower end of the tube, but that these tacks showed an entirely different ratio in the stream of air. If, for instance, the stream of air was so regulated that the tack (*a*) sank with the same rapidity in it as an exactly similar steel tack did in the water-tube at the same time, then would the shorter tack (*b*) be held in suspension by the stream of air, and could not be made to sink in it. Mineral grains which fall equally in still water or float together in an ascending stream of water, and which, consequently, can be no further separated in water by means of settling and slime apparatus, can, accordingly, be still separated in an ascending stream of air.

For the same reason, in order to separate different-sized grains of different specific weights successfully, according to their gravities, in an ascending stream of air, only a small number of sorting sieves is necessary for dividing into few grain-sorts, while the sifting in the hydraulic jigging process must give a much greater number of carefully-graded grain-sizes, and consequently need a greater number of sorting sieves. Mr. Krom, therefore, in his ore-dressing establishment, sorts the comminuted material into only four kinds, which are subjected to special treatment on pneumatic machines arranged for the purpose.* The dust blown and exhausted therefrom is guided into a special chamber, and there collected, and is not subjected to further concentration, because it forms only a comparatively small portion, one-sixth to one-twelfth of the prepared material, and, as a rule, attains twice the percentage in precious and base metals, in comparison with that of the stuff to be dressed; so that the dust is most advantageously brought without delay to the smelters. In the pneumatic concentrator the sized stuff can only be separated into two grades. The work is so directed, to avoid loss, that, in the first operation, merely dead refuse (berge) is got rid of. The remaining concentrated portion is jigged for the second time, and then gives pure ore and a middling product, which is again jigged, and, if necessary, once more reduced in size, and separated into the kinds of ore desired.†

The greatest difficulty of the treatment seems to lie in removing the ore-dust, which penetrates into the work-room, and is detrimental to health. Mr. Krom, for overcoming this difficulty, uses the well-known arrangements so successfully employed in glass- and stone-cutting factories for drawing off the dust. It might be expected that, by this means, the dust could be kept

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* The ore-bed (Erzbett) of these machines consists of a kind of grate with short square-shaped, hollow, grate-bars, which are formed of fine brass wire gauze, and leave intervals of $\frac{1}{16}$ to $\frac{1}{4}$ inch, according to the size of grain to be separated.

† Mr. Krom, in another place, publishes from the reports of the superintendent, T. G. Negus, the results of working up several lots of ore in the Dry Concentration Mill, at Star Cañon, Nevada. These ores, consisting of antimonial silver and silver glance,—black sulphurets of silver,—are uncommonly difficult to prepare in the wet-way. According to this report:

1. 66,800 lbs. from the De Soto Mine, with assayed value of $72·24 per ton, in silver, or 3·612 cents per lb., gave a total value of $2,413.

a. In concentrated ore of 3 sorts:
2,620 lbs., with total value in silver of $1,320 or 50·38 cents per lb.

b. In chamber-dust:

11,998	„	„	829	„ 06·90	„
Together 14,618	„	„	$2,149	„ 57·28	„ of the original quantity of silver.

2. 38,150 lbs. of ore from the Sheba Mine, with assayed value of $56·72 per ton, or 2·836 cents per lb. (a total value of $1,082), gave in—

a. Concentrated ore, in 3 lots:
2,813 lbs., with total value in silver of $789 or 28·04 cents per lb.

b. In chamber-dust:

2,881	„	„	139	„ 4·82	„
Together 5,694	„	„	928	„ 32·86	„ of the original silver.

The loss of ore or silver, therefore, amounted to nearly 11 per cent. in the richer lot, 1; to about 14 per cent. in the poorer lot, 2; or, in the first case more than one-half, in the second nearly three-fourths, of the original quantity of silver was obtained in highly concentrated ore.

from the work-room with some care. The arrangement of a Krom ore-dressing establishment, according to the building plans published by the inventor, consists of stories built over one another in the form of a tower, arranged to effect the greatest possible saving of transportation and manual labour. First of all, in the middle story, the material to be dressed is reduced to nut-size in a crusher, and then dried on a very steep step-grate, through which the gases of combustion pass to a fire-place lying underneath. The dried mass is then carried automatically, on an endless belt, to crushing rollers, and then, after sifting out the finely-ground parts, descends to a fine rolling-mill. The material ground fine enough is led into a lower hopper, over which there is a shaft-like, high, tightly-inclosed, forwarding tower, and in this is raised by an elevator. Near the forwarding tower are four drum-sieves, one under the other, inclosed in cases, and so arranged that the stuff sorted in the top drum is re-sorted in the lower drums, and in the middle story is received in four separate bins. There is a powerful ventilator near the tower, which exhausts the dust from the tower, and blows it through a long conductor to the dust-chamber. The dust forming in the crushing rollers is exhausted directly from beneath the rollers, through narrow conductors, which are connected with the tower. The drum-cases have equal-sized openings underneath, to admit air, and a side opening connecting with the tower, through which the stream of air drawn through the drum is likewise led to the tower. In this manner all the dust formed in the comminuting and sorting apparatus reaches the ventilator in the most direct way, and afterwards is deposited by it in the dust-chamber. Under the four bins mentioned, for the four sorts of grains, are the pneumatic jiggers, in two stories, one under the other, and, in fact, in the upper story there are four pairs of jiggers, to which each one of the four kinds is conducted directly from the bins above, for working up. In the lower story are two more pairs of jiggers, for refining the material concentrated in the upper jiggers. The resulting refuse, containing ore, which arises therefrom, is once more jigged, and the impure middlings thereby obtained, mixed with country rock, are carried to the fine mill for further comminution. Such an ore-dressing establishment, provided with twelve jiggers, is said to work up from two to three tons of ore-stuff per hour, and to need six workmen by day and three by night, where steam is used, or five by day and two by night where water is employed. A separator is said to need $\frac{1}{5}$ horse-power, on an average, and costs in New York $600 to $700 (2,250 to 2,812 marks).*

The cost of dressing with steam is said to be two dollars (7½ marks) per ton of raw ore, but with water-power only half that amount, wages and repairs included. Evidently these statements can be considered only of approximate worth, and vary with the richness, hardness, and other qualities of the ores. Krom's treatment has not yet been applied to coal-dressing, but, perhaps, even with it, may be of use; for it is, precisely, the finest particles, a valuable material, which, from their being drained off by the water, cause the greatest difficulties in wet dressing, that are saved in a dry condition by means of the ventilator in the pneumatic process. Of course, effectual regulations for safety against fire must be made everywhere. With still greater certainty it may be assumed that the cleaning of ground rock-salt from anhydrite can be effected cheaply, and with the best success, in this simple way; because the anhydrite in it ordinarily occurs in hard, compact grains, which can be expelled directly frem the mill in *one* operation without the least necessity of manual labour.†

IV. Comminuting Machines.

1. Crushers or Stone-Breakers. — The breaking up of the heavy ore-gangue (Wäude), obtained from the mine, has been effected, almost exclusively, by means of hand-labour, until within a comparatively short time,

* Mr. Krom also furnishes small pneumatic model machines adapted to laboratory purposes at the price of $250; and also small crushers of peculiar construction adapted to the same and weighing about 1,000 lbs. at $450.

† It is said that the process has already been made use of with success in cleaning coffee.

just as the breaking of stone for road ballast is still done chiefly by hand-hammers. Very recently, at the Quincy Mine, on Lake Superior, heavy drop-hammers have been used for breaking up coarse gangue containing ore, which are managed after the manner of the machines in use for breaking up large ore masses. They are especially serviceable for coarse pieces of native copper, which cannot be broken in the crushers, in separating the copper from the gangue united with it, and in hammering clean the lumps of copper. When it is considered that hammers of any kind are expensive to set up, because of the foundations necessary, are difficult to use, and are of little efficiency, and that they, therefore, have been used to only a limited extent, dependent on local circumstances; then, the invention of the stone-crusher by Eli Whitney Blake, of New Haven, Connecticut, in the year 1858, seems an extremely important advance. According to the statements of the Blake Crusher Company, there were at work in the United States alone, at the time of the Centennial Exhibition, 509 such machines of various sizes. They are spread in every direction, and are frequently used for building purposes. The strongest machines are found at the Calumet and Heckla Copper Mine, on Lake Superior, where blocks of ore weighing 1,000 lbs. are broken by them. The No. 5 machine shown at the Exhibition, with a jaw-opening of from 9 to 15 inches, is said to break hourly about nine tons of stone or ore into pieces $1\frac{1}{4}$ inches in diameter, with a motive force of nine horse-power, at 250 strokes per minute.

The mouth of the machine, opening upward, is provided with a movable jaw, to which a rapid biting movement, reaching as high as 250 strokes per minute, is given by means of a heavy eccentric lever and toggle-joints, driven by shaft and pulley, with a balance wheel. The return of the movable jaw is caused by means of an india-rubber spring at the end of an iron rod. For setting up the jaws a double wedge is used, resting against the frame and serving as fulcrum to the toggle-block. The two toggles consist of cast iron plates of a strength that will allow them to break when the fragments of mineral offer too great resistance. The heavy cast iron frame, consisting of only one piece, gives support to the fixed jaw and to one toggle, and also serves as a bearing for the pivot of the movable jaw and of the eccentric pitman. The jaws are lined with chilled iron, either ribbed or corrugated. These face-places can be turned upside down when rendered necessary by the wearing away of the top, which occurs first and quite rapidly with very hard material.* The face-plates have, therefore, lately been so arranged that they can be divided in the centre, so that the lower part, when worn away, can be exchanged with the upper part, which has been less exposed to wear. The cheap preparation of cast steel, by Bessemer's or Siemen-Martin's methods, or by the late treatment at the Terre Noire Steel Works, in France, is extremely useful for this purpose.

Numerous breaking machines, varying more or less in construction, have been used in Europe; in France, those of Huet and Geyler; in Germany, those of Schwarzkpoff, without, however, producing any essential improvement on Blake's machine.

A crusher has been used lately in England under the name of H. R. Marsden's Patent Blake Stone Breaker, and is made at the Soho Foundry, of Leeds. Instead of the rubber spring for drawing back the jaw, it is provided with an adjustable, angular lever, between the lower end of the pitman and the movable jaw. The face-plate of the latter is besides composed of two portions, which are fastened to the jaw by means of screw bolts through a wedge-shaped piece inserted between their adjacent bevelled ends. The changing of the face plates is said to be facilitated thereby, and the wear lessened in such machines.†

2. Crushing Rollers. *a. Ore Rollers.*—The crushing rollers first used in Cornwall, in the beginning of the nineteenth century, are of still greater importance in ore dressing, because with them gangue (of about the size of

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* In experiments at the Scharley Mine, in Upper Silesia, the face-plates lasted scarcely a day while breaking tempered, high-furnace slags; but endured a year in breaking limestone. Gätzschmann's *Aufbereitung*, vol. ii., p. 674.

† *Mining Journal*, 1877, Supplement, p. 190.

the first) can be reduced sufficiently to separate the dead rock from the ore mixed with it. The horizontal adjacent pair of rollers were originally provided with ribs or ridges in order to seize coarse pieces of ore more easily. Such comparatively long and thin rollers were in use more than 25 years ago in the Hartz Mountains, introduced there in 1831.

In Cornwall, in 1830, smooth rollers of large diameter and short length were found serviceable* for crushing coarse stuff. Such rollers were first introduced from there into the Rhenish ore mines in the year 1850.

At present smooth rollers are in common use for dressing ores. The middle products from the jigging process, in which, for instance, galena is intermixed with blende or gangue, and which, as a rule, are not more than two centimetres in diameter, are ground in rolling mills with less diameter of rollers.

In the coarse rolls, which work with the very heavy pressure of from 20 to 25 tons counterweights, it is advisable not to exceed a velocity of the circumference of over 20 to 25 metres, because otherwise fractures easily occur on account of the resistance of the counterweight. In the Rhenish ore dressing establishments, where rubber or steel springs are used for pressing the rollers together, 60 and even 90 metres velocity of circumference is allowed, without, however, increasing the working capacity, with the consequently reduced pressure of rollers, as compared with slower work and a heavier pressure. The more or loss soft nature of the ore must, in each case, decide which treatment it is advisable to use. The use of springs has lately been preferred in order that the softer ores may not be crushed too fine and loss be thereby created.

The danger of fracture is essentially lessened by transmitting the driving-power by means of belts or friction rollers. In such contrivances for fine rolls, the position of the rollers is fixed by set-screws. The two axles, on which the annular rollers are fastened, are provided with a pair of toothed wheels working into each other, and such a length must be given to the teeth that they will not be thrown out of gear when the rollers separate. Coarse rolling-mills have, therefore, involute gearing, with very deeply-cut teeth. The annular roller is worn away rapidly by hard material, and is, therefore, generally made of either chilled iron or cast-steel. It is essential to be able to turn down the rollers from time to time, because they wear very unevenly.

Mr. Krom, the inventor of the pneumatic jigger, has added an extremely complete contrivance (patented in the United States in the year 1872), to the crusher which he used in his ore-dressing system, by which he brings the power upon and between the rollers, and at the same time turns them.† The fastening of the steel roller-rings on the shaft, by means of wedge-shaped press-ring pieces, drawn up by screws, after the manner of William Seller's shaft coupling, is especially deserving of attention. The shafts are very strong, made of steel, with a thickness of 196 millimetres (7¾ inches) in the middle and 160 millimetres (6¼ inches) at the journals. Each roller receives its motion independently of the other by means of a toothed wheel, 102 centimetres (40 inches) in diameter, working in a pinion of 33 centimetres (13 inches) in diameter. The pinion of the movable roller, with its correspondingly larger toothed wheel, lies on one side of the frame, the pinion of the stationary one on the other.

The first is on a special shaft driven by an intermediate wheel, which is so arranged that it can be lowered a little, in order always to give the toothed wheel a proper bite on the material, when the roller becomes smaller in diameter from use. In the rolling-mill represented, steel springs are attached, in order to let too hard pieces pass through without breaking the machines. As a rule, however, Mr. Krom uses, instead of springs, cast-iron plates, as bearings for the ends of the press-bar of the movable journal. These plates, the

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* Karsten described in 1831, in his *System of Metallurgy*, vol. ii., p. 106, not only several crushing rolling-mills with thin, ribbed rollers, at the lead mines in Flintshire, but also a dressing establishment at the copper mine, Towey Consols, in Cornwall, in which the pair of rollers were pressed together by weights, which act by means of levers on the movable bearings of one of the rollers, and where, at that very time, they had erected a new set of crush-rolls, with rollers of 34 inches in diameter, and 17 inches in length.

† The descriptions and drawings are taken from the previously-mentioned publications of the inventor.

so-called breaking pieces, are so constructed as to yield at once, when there is too great obstruction between the rollers, and can then be replaced by pieces kept on hand. The slide-rest, which can be fastened to the upper or lower end of the roller frame, as is most convenient, is used for turning down the rollers when worn unevenly. From 50 to 60 tons of rolling-stuff, varying as the gangue mixed with the ore is silicious or limy, can be worked up in 10 hours, in a coarse rolling-mill, constructed on the English model, and requiring 10 horse-power to run it. From 5 to 20 tons can be worked up, in the same time, in a fine rolling-mill, with from 2 to 4 horse-power.

At Schwarzmann's friction rolling-mill for fine reduction, at Ammeberg, in Sweden, a rotating, flat disc, driven by the engine, is inserted between each pair of rolls, and carries them with it, working in a similar manner to a collar-mill.

b. Coal-Crushers.—The comminution of coal takes place either for the purpose of breaking up the coal obtained into pieces of a suitable size for the market, or to separate the coal from the accompanying foreign ash-producing portions,—slate, iron pyrites, and earthy coal,—and then to wash it clean. In both cases, the endeavour is to so arrange the rollers that they act on the pieces of coal as little as possible in a crushing or grinding way, but more in a splitting manner, in order to obtain the smallest possible amount of worthless coal-dust in the first case, and, in the second, to avoid grinding into fine dust the soft pieces of fuller's-clay and clay-slate, which cannot be separated from the fine coal-dust in the further dressing. Rollers for breaking up anthracite were first employed in Pennsylvania, in the year 1843, according to Gätzschmann. Afterwards, to the rollers in that locality were added diamond-shaped, blunt, tooth-like, projections working toward one another, while the body of the rollers themselves, made of cast-iron, was provided with indentations arranged in right and left spirals crossing each other.

The toothed rollers, on the one hand, produced much useless coal-dust, and on the other, it was found necessary to throw away a roller when a few teeth were broken out. Lately, cylindrical rollers have been used there, with cast-steel teeth inserted. Smooth cylindrical holes of exactly equal diameter are bored radially, in lozenge-shaped places opposite each other, in the casing of the rollers, and into these holes the steel projections, provided with cylindrical shanks, turned so as to fit accurately, are driven firmly. The lancet-like projections are slightly bent in the direction of the motion, in order to seize and split the pieces of coal with more certainty.* If a tooth breaks off, the shank, still remaining in the cylinder, is driven through the hole, and a new tooth is inserted. For this reason, the toothed roller, though at first cost somewhat dearer than the old cast-iron one, is much cheaper in the end. Besides, the work is increased with the same power, and the loss in worthless dust is diminished. The machine represented likewise shows various important improvements for the safety of its working, in regard to the motion and bearings of the shifting roller, which can be recommended for ore-crushing mills also. The bronze bearings, for instance, are provided, above and below, with parallel planed surfaces, so that they can be shoved into a box-like cavity in the roller-frame. The middle portion of the bearing forms an upright cylinder, from which the ends of the bearings project sidewise like annular shoulders. Elliptical cast-iron rings lie, as break-pieces, between the bearings and the set-screws; the latter are adjusted equally by means of a motion common to both. If such a break-ring gives way, the roller, with its bearing set free, can recoil without obstruction, while the other bearing turns on its cylindrical part. By means of this arrangement, which works in a similar manner to the ball-joint journals, as smooth a revolution as possible of the axle is produced, with diminished friction and wear, notwithstanding the heavy vibrations to which the movable roller is exposed. The box-like frame pieces are each provided with an accurately-fitting cover, which prevents the lifting and sliding of the movable bearing.

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* The Centennial Exhibition contained such a coal-breaking machine shown by Coxe Bros. & Co., of Drifton, Luzerne County, Pennsylvania, and constructed and finished by D. Clark & Co., of Hazleton, Pennsylvania.

In Germany, rollers which are provided with sharp, projecting ribs, are used in the crushing-mills of coal-washing establishments. To prevent the interfering of these ribs, they are wound around the cylindrical roller in steep helices laid crosswise, so that lozenge-shaped depressions remain between the ribs; but even for such coal-washing establishments, the improved American toothed-rollers with narrower roller-space may be adapted.*

3. Mills.—Under the head of mills are mostly understood such commuting contrivances as produce the finest meal possible, without regard to sparing the grains obtained. Together with the mill used in amalgamation of gold and silver ores, we must here consider especially the rock-salt, gypsum, and other mills. While we pass over the amalgamation-mills as metallurgical affairs, we merely mention that the breaking up of rock-salt is performed in three successive operations adapted to the purpose. The first operation consists of a breaking up of the heavy blocks to nut size, in simplified stone breakers; the second follows in the so-called coffee or cone-mills; the third, in common runner-mills, with mill-stones quite similar to those of a corn-mill. The cost of grinding varies from two to three marks per ton of rock-salt, according to the degree of fineness of the meal required.

The Dingey mineral-mill, lately came into use, first in England, then in the Spanish, German, and other ore-dressing establishments, for reducing finely-disseminated ore-stuff to a further degree than can be done by fine rolling-mills. This machine consists of a horizontal, slowly rotating, furrowed plate, upon which four discs, likewise furrowed, revolve rapidly in the opposite direction. The mineral grains are torn by the surfaces of the plates and discs, made of hard cast-iron or steel, working against each other under water, and are then thrown as slime through a sieve which forms the edge of the plate.

This machine with the same motive-power and half the supply of water is said to do double the work of a stamp-mill, and, at the same time, to make less tough slime, to reduce better for the jiggers, to work with less noise, and to demand less repairing, on account of the diminished and more even wearing of the parts rubbing against each other.†

4. Stamp Mills. — A hundred years ago, besides the stamp mills, a hammer-stamp was used, which worked in a similar manner in many respects. With the advance of technics, the simple arrangement of a perpendicular stamp, which was raised directly by a cam-shaft, has taken the place of the complicated piano key-board arrangement of a hammer stamp-mill. Even dry stamping-mills are no longer used for dressing ores, except in chlorination and amalgamation works. We have, therefore, to do here merely with wet stamping mills, in which the cast-iron or steel shoe (Pocheisen) of the stamp works upon a cast-iron bottom, or one of hard, stamped quartz, placed in a deep stamp-trough filled with water, generally called a "mortar," and in such a manner that the perpendicularly guided stamps, placed in a frame between the upright posts of the stamp-frame, are allowed to rise and fall alternately, in regular order, by means of the cams distributed upon the horizontal stamp, or cam-shaft, working upon a horizontally projecting arm, — the tappet, — attached to each stamp. Numerous local peculiarities occurred, in the beginning,

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* Carr's *Disintegrator* has also been used in Belgium for breaking up coal. In the experiments which have come to the author's knowledge, this machine has seemed adapted to soft, earthy substances, like chalk, burnt gypsum or lime, mineral manures, &c. With harder substances, such as rock-salt, the so-called coffee-mill proved better adapted and more efficient. We cannot, therefore, reckon the disintegrator among the apparatus to be considered in the development of ore-dressing. According to Pernolet (*Annales des Mines*, 1874, 7e sér., tome vi., p. 365) Carr's Disintegrator, of which very good drawings are there given, has been in use in coke establishments, at Anzin, since 1869, for mixing, and at the same time reducing to finer dust rich and poor small coal, without preparing this dust further. An apparatus, 29 centimetres wide, with the greatest diameter of the disintegrator cylinder 120 centimetres, and driven at 350 revolutions per minute, worked up hourly 15 tons of small coal, and required 15 horse-power, or 1,124 kilogram-metres, for working up 500 kilogrammes of fine coal per minute, while for the same work, in competitive trials, a crushing-machine needed only 5 horse-power.

† Report on *Ore Dressing*, by C. Sacks (Technical Director of the Humboldt Stock Company, at Kalk, near Cologne, where such mills, improved in form, are used), to the journal *Berggeist*, April 1877, pp. 105, 109, 113, 114. A Dingey mill of 2·29 metres diameter of drum, and a total length of about 2·5 metres, is said to have worked up per hour about 800 kilogrammes of quartz jigging-stuff, with 207 revolutions of the 4 disks and 2·2 revolutions of the plate per minute, using about 8 horse-power and a mesh of 0·5 millimetres.

in those constructed of wood, the bottoms and shoes excepted. In some places five stamps were used in one set, in others only three. In the first and older arrangement the bottom was inclined, so that the water entering at one end of the trough carried the comminuted mineral off through a hole made at the other. In the latter method, now commonly followed, the removal of the stamp-stuff is effected either on one or both sides of the trough, through grated sieves or a horizontal slit.

Fifty years ago stamp mills were driven by water-wheels only. At least three cams for each stamp, equally distributed around the circumference, were accordingly set into the slowly revolving, thick, wooden shaft. With the latter use of the steam-engine, first adopted in Cornwall, and soon after in Spain, and the still later use of turbine-wheels for driving stamp mills more rapidly revolving, thin, iron shafts came into use, and it was, consequently, found necessary to use only two, and, in some cases, only one cam for each stamp. Mr. Pernolet, in the year 1849, made a report on similar single-lift iron shafts, which he had seen in Southern Spain.* As the stamps were raised perpendicularly in order to diminish the friction of their guides, and as, therefore, a horizontal surface of contact was given to the under side of the tappet, the desire for as uniform a lift of the stamp as possible has generally led to the construction of the friction surface of the cam on an involute from the circle of friction itself. The lowest position of the tappet surface, must therefore, correspond with the level of the axis of the cam shaft, and, accordingly, the tappet must be adjusted in a perpendicular direction, in or on the stem, at about the height to which the iron shoe wears by use. The thinner the iron shaft the smaller must be the diameter of the involute circle, and therefore with double, and still more with single-lift shafts, so much greater must be the length of surface of the involuted cam that rubs against the friction surface of the tappet, in order to arrive at the required height of lift. It is further necessary to let the tappets also project a correspondingly greater distance, at right angles to the stem, in order that the cam may pass by the stem without striking it, or the stem must be slit up, so that the friction surface of the tappet shall lie in the stem, and the cam move freely through the stem to this friction surface. Certain disadvantages are connected with both methods, and therefore the sliding friction, which, according to simple mechanical principles, is proportional to the distance passed over by the cam on the friction surface of the tappet, and therefore increases exactly in proportion to the length of the involute, requires especial attention.

In the year 1856, the author had to construct stamp mills, to be driven by rapid turbine wheels, for several ore-dressing establishments of the Schwatz Mining Union, at Schwatz, in the Unterinnthal circle, in Tyrol. In order to simplify the transfer of the motion single lift-shafts were used. A peculiar construction, differing essentially from the customary plan, and which has proved perfectly satisfactory, had to be used to avoid the above-mentioned difficulties, and, for this reason, it deserves discussion here; particularly as the methods of constructing the cams are given in a more practical way than in the published text-books, which give only the pure involute construction, which often cannot be recommended. In order to diminish as much as possible the shock of the cam against the tappet, it was assumed that, with 80 revolutions of the shaft per minute, or one revolution in 0·75 seconds, and with a rise, $h = 261$ millimetres, the lift would take place with a velocity of only 0·624 metre per second. But the tappet in falling, from an occasional breaking off of the stem or shoes, could not reach the cam-shaft. From this resulted a periphery of the involute circle of $0{\cdot}75 \times 0{\cdot}624 = 0{\cdot}468$ metre, corresponding to $r = 75$ millimetres radius, and the greatest radius of the cam $R = \sqrt{r^2 + h^2} = 272$ millimetres. By using the pure involute of the original circle, of 75 millimetres radius, a revolving angle of 201° would be necessary for the shaft, if the involute were developed to the distance of the greatest radius, R, from the middle point of the shaft, and the length of the friction surface would be 460 millimetres. A falling-time of 0·23 second would be necessary for the free fall of the stem, $h = 261$ millimetres. From

* *Annales des Mines*, 1849, 4e sér., tome xvi.

the beginning of the fall till the beginning of the next lift there was an interval of $(360 - 201) \div 360 = 0{\cdot}442$ of a revolution, or 0·33 second to account for; therefore there remained still for the stem a pause of $0{\cdot}33 - 0{\cdot}23 = 0{\cdot}1$ second between its fall and lift.

For practical reasons it appeared desirable to prolong this pause. The stem, which after the fall still vibrates, should come to a rest during the interval. Further, the length of the cam should be diminished, and, finally, the friction between the cam and the tappet be reduced, partly through a suitable shortening of the friction distance, partly through dynamic lessening of the friction-pressure. For this purpose only a small portion of the friction surface of the cam was constructed according to the involute, sufficient to raise the tappet, with the slight initial velocity of 0·624 metre per second, to a height of 104 millimetres, or sufficiently high to prevent injury to the tappet by reason of the difference of its height during the lifts, caused by the unequal heaping up of the stamp-stuff and the wearing away of the shoe and die. The remaining curve of the cam was formed by two arbitrary circular arcs of 288 millimetres and 32 millimetres radius. By this means the stem, leaving the involute, received an increased velocity of lift of 0·624 metre, then of 0·86 metre, and finally of 1·25 metres per second, which again diminished, during the last 16 millimetres of the lift, before the fall of the stem, to 0·78 metre per second. The involute cams act only on the outermost edge of the tappets, and thereby produce a rapid wearing away of this edge. In the described prolongation of the initial involute into a flat circular arc, the length of the friction surface is considerably increased, and, in the construction under consideration, is, in fact, as great as 10 centimetres. The line of contact slides forward and back on the under surface of the tappet. Rolling friction on the tappet takes place during the greatest rapidity of lift, and the stem jumps up without side-pressure.

A very wide removal from one another of the mutually rubbing surfaces of contact is, however, prevented at that period of lift in which the velocity of the lift decidedly diminishes; consequently, according to dynamic laws, the pressure between the surfaces of contact and friction must correspondingly diminish.*

The fastening of the cam on the shaft, 117 millimetres thick, offered a further difficulty, because, with a small diameter of the involute circle, of only 150 millimetres, the cam could not be provided with a ring running around the shaft. This difficulty was solved in a very satisfactory manner, by means of a peculiar construction, which permitted each cam to be exchanged at pleasure, without removing the other cams, or even lifting the shaft out of its bearings. The stamp-mills were arranged in two sets of eleven stamps each. The stamps of one set were so divided on the shaft that the neighbouring stems stood nearly diametrically opposite. The cams were provided with a prolonged foot with ear-shaped flanges at both ends and hollowed out in the middle, so as to fit on the cylindrical and unturned surface of the shaft; and the ear-shaped flanges of both ends turned opposite to one another in such a manner that the flanges standing diametrically opposite each other may be brought with their ears into the right position to fasten them firmly, by means of a pair of screw-bolts outside of and close to the shaft.

In this manner, 24 bolts are sufficient for fastening the 11 cams of one set, and a valuable stiffening is given to the shaft itself by the plate-like foot-pieces, which in a certain measure are wound about it in two helices. To prevent the turning of the cam on the shaft, and to fit the cam itself properly, every cam-foot is provided, on one end of the curved surface of support, with a blunt, conical nose, by which the foot is caught in a corresponding conical hole bored in the shaft. So far as the author has had an opportunity to observe these stamp-mills in operation, this construction has proved very efficient. They can, without doubt, make 80 lifts per minute, while a beautiful polish is soon formed on the rough cast-iron surfaces of contact of

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* Instead of the flat arc of the cam a straight surface can be used, if its short rounding and is only preserved as a friction surface; for it appears improbable that a still greater velocity than 1·25 metres per second can be given to the stamp already set in motion, and therefore shocks can no longer occur.

the cam and tappet, which are not finished at all, but mutually grind each other; and this polish lasts a long time, with moderate use.

In the most recent stamp-mills of the great central ore-dressing establishments, at Clausthal,* in the Hartz, it has been found, after careful experiments, that it is more advantageous for the work, and saves water, to unite as many iron stamps as possible, say nine, in one set, and to make the space between the shoes very small. By crowding them together the punching of holes in the bottom is avoided, and the wear of the latter is diminished. The cams are fastened there by screwing them together on an iron double-lift cam-shaft, in a similar manner to the above construction.

In the gold and silver mines in the Western part of the United States, stamp-mills with self-revolving iron stems are in common use. According to Gätzschmann, the idea of diminishing the friction between the cam and the tappet by revolving stamps had been previously expressed in the year 1844, in Hülpe's polytechnic *Centralblatt*, p. 110, for a chopping stamp, with a stationary arrangement of cam-shaft, around which four stamps were placed in a circle, and later by Schwahn in his *Mühlenbaukunst* (sec. vi. p. 31).

The practical introduction of this improved California stamp-mill for ore-dressing, as well as its invention, is due to Joseph Moore, of San Francisco, who obtained a United States patent for it May 6, 1862.† These stamp-mills work partly in the wet, partly in the dry way, according to demand; but generally in direct connexion with metallurgical processes, without further concentration of the slime by mechanical dressing. A gold-quartz, wet, stamping-mill of this kind and its amalgamation mill, in full operation, were exhibited by the State of Nevada at the Centennial Exhibition.

A full destription of such a stamping-mill, with drawings, by Mr. G. F. Deetken, of Grass Valley, was published in the official yearly report of the Treasury Department, at Washington, for the year 1873.‡

Mr. P. L. Burthe has made the most important details accessible to the readers of the *Annales des Mines*, in his notes of travel, given to that widely-circulated journal.§

The battery-frame (Pochstuhl) is constructed of wooden beams, with a foundation usually directly upon tho bed-rock. The cast-iron trough, "mortar," for each set of five stamps is made in one piece, which rests on strong wooden blocks, "mortar-blocks," and is let into the battery-frame on both sides. In the long mortar lie, in close proximity, the "dies," made of hard cast-iron, one for each stamp. These dies have a four-sided foot-plate, with truncated corners, to stand upon the bottom of the mortar, and they end above in a cylindrical head of the same diameter as the "shoe" (Pecheisen) that strikes upon it. The stamp consist of four cylindrical parts:—the shoe, the head or boss, the stem, and the tappet or lifter, and weighs from 600 to 900 pounds. The shoe has a conical or tapering shank, which fits into a corresponding recess in the head. A cylindrical hole in the upper side of the head contains the lower end of the stem, which is 13 to 15 feet long and 3 to 3½ inches thick, while the head and shoe together form a cylinder about 20 inches high, and 10 inches diameter. At the end of the two cavities in the head are two transverse slots, which are used in loosening the shoe or the stem. The tappet is fastened to the stem by means of an inserted bar of iron called a "gib," and two wedges driven in transversely, and, after the lower surface of contact is worn out, it can be removed and replaced on the stem, upper end down presenting a new contact surface. The iron cam-shaft, about 5 inches thick, is placed as close as possible to the stamps, with an offset of only 5 inches from both centre lines. The double lifting cams and the hub, which has one side elongated, are cast in one piece. This hub is forced upon

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* The Clausthal Works. *Engineering*, 1876, vol. xxi., pp. 35, 64, 102, 167, 210, 249, 303, 356. An earlier description of this interesting establishment is given by Kutscher in *Der Zeitschrift für das Berg-, Hütten-, und Salinenwesen in dem Preussischen Staate*, vol. xxi., 1873, p. 85, before the improvements of Meinecke, civil engineer at Görlitz, were introduced.

† There was a model of Moore's patent, with the inscription, "Revolving Stamp Mill," in the Washington Patent Office Exhibition, in the Government Building, at the Centennial Exhibition.

‡ *Statistics of Mines and Mining in the States and Territories west of the Rocky Mountains; being the Fifth Annual Report of Rossiter W. Raymond, United States Commissioner of Mining Statistics.* Part II., p. 319. Washington: Government Printing Office, 1873.

§ Burthe, *Notice sur les gisement des minerais d'argent aux États-Unis, Annales des Mines*, 7e sér., tome vi., p. 9, 1874.

the shaft, which is turned smooth and has two key-seats cut in it, and keyed thereon. The hub has an iron ring over the elongated end, to prevent bursting. The cam-curve is the involute of a circle, whose radius is equal to the 5-inch offset of the centre lines of the shaft and the stamps. On its outer end it is curved about $\frac{3}{8}$ of an inch more, because, at the end of the lift, the point of application is forced out of the centre line of the stamps to the circumference of the ring-shaped contact surface of the tappet. For a lift of 10 inches the length of the cam-curve is 546 millimetres (21½ inches). From 50 to 60 lifts are made per minute, according as the stamp is heavier or lighter. The wear is reduced by a twisting motion given to the stem at each lift, and thereby the shoe and die are used equally. The upper and lower guides to the stamps are made of two blocks of pine, hollowed out to fit the stem and screwed together. To sustain the screens, a cast-iron flange, or frame, is bolted to the side of the mortar, and in it is a row of rectangular openings, before which the screens, in window-shaped frames, are screwed.

In the California stamp-mills the feeding of the ore requires especial care, because, after continued use of the shoe or die, the tappet in falling strikes upon the hub of the cam, and may cause breakage; therefore special workmen, called "feeders," are employed for this purpose. In the German and Cornish stamp-mills the tappet cannot strike the shaft or hub of the cam, because it is placed on the side; on this account self-acting feeders have in those countries been pretty generally used for some time. Within a few years such arrangments, indeed, have come into use in California too. In Cornwall they have lately used the so-called "atmospheric stamps," according to Gätzchmann, invented by Hughes, and also at the Phœnix Mine at Lake Superior. These have been described and illustrated in English and American publications,* though the particulars, which the author himself saw at the Phœnix Mine, differ somewhat from those.

The cast-iron stamp is raised by means of an air-compressing cylinder, of 4½ inches diameter, bored in it, in which a double-acting piston, packed with a leather gasket, works up and down, moved by a crank-shaft. The air-cylinder is long enough to allow the piston free play. Above and below the middle point of the piston the cylinder-jacket is pierced with holes, so that the piston passes through the first half of its up and down stroke in the cylinder without resistance from the air; but there it shuts off the air in the ends of the cylinder and compresses the same. In this way the stamp is lifted by means of an air-cushion during the upward motion of the piston, and in the downward motion its fall is hastened. The upper part of the mortar is provided with a cylindrical neck cast upon it, in which each stamp (about 6 inches thick and of 1,100 pounds weight) plays perpendicularly. In order to reduce the consumption of water, it is brought into the mortar from above, through the space between the neck and the stamp. From five to six stamps in a set have a mortar and cast-iron bed in common. The shaft lying over the centre line of the stamps is bent frequently at right angles, so that the five or six cranks lie close together between the end-bearings of the shaft.

The principal advantage lies in the quick motion, which at the Phœnix Mine reaches 140 lifts per minute, or double the velocity of the much lighter stamps of the California mill. Still the piston-packing and the air-cylinder in the stamps wear out rather fast, and therefore require frequent repairs and changes. Only two of the three batteries at the Phœnix Mine are used at one time, while one is always kept in repair.

Under the title of "Sholl's Patent Pneumatic Dead-Blow Power Hammer," there has quite recently come into use in England a one-stamp steam mill, working directly, after the manner of a steam-hammer. This is arranged in a way similar to the steam stamp mill of Ball, described hereafter; and the transmission of power from the steam piston to the stamp takes place in just the same way as in the above-described mill,† by means of a piston and air-cylinder. Of the greatest importance to the copper mining interests of

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* John F. Blandy on the *Stamping Mills of Lake Superior, Trans. of the American Institute of Mining Engineers*, vol. ii., p. 212.

† *Engineer*, 1876, vol. xlii., p. 5.

Lake Superior has been the above-mentioned Ball's steam-stamp, invented some twenty-five years ago by William Ball.

This machine, which was in active operation at the Centennial Exhibition, is constructed upon the principle of Nasmyth's steam hammer; yet, in the particulars of its construction, it has a number of peculiar arrangements, by means of which the inventor and his heir, during the twenty years since its first introduction into the Lake Superior region, have succeeded in establishing a stamping-hammer as powerful in its work as it is a practically useful, enduring machine of a perfect type.

The importance of this invention for the cheap dressing in bulk of the very poorest copper ores at Lake Superior is shown by the fact that 26 such stamps, mostly of the largest size, are in use there, of which each one stamps 120 tons of hard ore in 24 hours; that is, as much as a California mill of 50 to 60 stamps. Such a hammer weighs 4,500 pounds, and makes 90 blows per minute, with a lift of 28 inches, the diameter of the steam-cylinder being 12 to 15 inches, and the working strength 30 horse-power. The high-pressure steam of 6 atmospheres, after being used in the hammer, is usually in separation works conducted into a low pressure engine, which drives the remaining apparatus in the works, and thereby a great saving of fuel is effected.

The separation works of the most important of these copper mines, the "Calumet and Hecla," of which a beautiful model was to be seen at the Centennial Exhibition, worked up in the four years 1872 to 1875 inclusive, reckoned from May 1 to May 1, with their seven Ball stamps, a total of 880,920 tons of hard stamping rock, making a yearly average of 220,230 tons, or in one day of 24 hours 734 tons, and, since only six of these machines were working at once, each stamp crushed 122·35 tons in 24 hours.

As a rule, at least three of these stamps are used in an establishment, in order to avoid any interruption of the work, if a stamp is to be cleaned, or any parts of the mortar thrown down during the operation are to be replaced. For this reason Mr. Ball also makes a smaller-sized stamp for less important mineral products—the smallest size, with a 650-pound stamp, a 6-inch cylinder, and 8 horse-power, stamping out 15 to 20 tons of rock in 24 hours, at the rate of 120 blows per minute, with a lift of 18 inches. The piston velocity with which this machine works amounts, accordingly, to 360 to 420 feet per minute, while the highest reached in the atmospheric stamp-mill is 210 feet, and in the California mill the average is only 100 feet, the highest 120 feet.

While Ball's machine, with a 4,500-pound stamp, crushes 120 tons in 24 hours, in other words requires only 38·5 pounds weight of stamp for each ton of ore, the heavier California stamp of 850 pounds crushes 2 tons in 24 hours, requiring for each ton of ore a stamp weight of 425 pounds, or 11 times the amount of iron in the other stamp for the same execution. To be sure, in this comparison, we have not considered the unequal hardness of the rock in amygdaloids, conglomerate and quartz, as well as the difference in the grade of comminution at the copper mines and the gold stamp-mills, by which circumstances the execution of the latter is considerably diminished.*

But, from the fact of the powerful Ball stamp having shown itself at Lake Superior, the most preferable apparatus for stamping out native copper from the gangue, we must not necessarily infer that is in like manner suited to the separation of gold from gold quartz. For soft silver-lead ores, or for so-called dry silver ores, the lift-stamp with a high lift has been found, after old, well-established experience, more advantageous than the heavy one with a low lift, because the latter tends to the dead-stamping of the more valuable ore particles. Results of experience in the use of the Ball stamp for such ores have not been made known. Since, on this account, according to the present laws of technics, the principal operation is performed by crushing rollers, and only a comparatively small part of the ore to be worked is brought to the

* The relation of the rocks causes great differences in other respects also. At the Pewabic Mine, at Houghton, where a very hard conglomerate was stamped with four of Ball's hammers No. 2, with a 3,500 lb. stamp, and the execution of one stamp in 24 hours was 70 tons of stamped stuff, the author was informed that the wear on the shoe and appurtenances amounted to 1 lb. of iron per ton of ore stamped, while in the case of mild trap-rock and amygdaloids it was only one-sixth to one-fifth of a pound.

stamps, in case such enter at all into the question; therefore, in such a case, only the smallest ball machines are to be considered, whose weight of stamp agrees with that of the California stamp mill, and then the question is only whether such small, quickly moving steam-stamps or the usual, slower, lighter stamp-mills deserve the preference.*

In the Ball stamping-machine the rather thick stamp is provided with a clutch below, to fasten the shoe to—as in certain steam-hammers, and above, with a disc-shaped end. The latter is bolted to a cast-iron buffer-box, which hangs on the end of the thin piston-rod, also disc-shaped. Above and below the latter named end are india-rubber discs pressed into the box; so that the stamp is lifted in an elastic manner, and the jar of the stroke is not transmitted to the piston rod. The iron piston rod is thereby protected from a change of texture from the jarring as well as from breaks. Under the spring-box the stamp is carried directly into two collars which lie upon a strong rim. Between these two stationary collars a third movable collar, provided with a belt pulley, is fastened to the stamp stem by means of a groove and spring, imparts its rotary motion to the stem. The rotary collar is moved uninterruptedly by means of a belt passing over the pulley, led from the driving-engine of the establishment, independently of the stamp-hammer. Under the steam cylinder the piston-rod passes through a second, stationary buffer-box, situated on a strong cast-iron cross-beam, against which the movable buffer strikes. By this means the upward play of the stamps is limited, and the steam-piston is prevented from striking against the upper head of the cylinder. Besides the principal steam supply-pipe, the cylinder has several small openings below for the steam to enter by; but on account of the thickness of the piston-head, situated higher up than the former. These are thrown open above the piston, as soon as the layer of ore upon the bottom has been stamped away, by reason of insufficient feeding, before the shoe strikes upon the bottom. On account of the steam entering by the above-mentioned openings above the piston after its descent, that remains standing, and the machine cannot be put in action again until the mortar is sufficiently filled with ore and the stamp raised by the workman. The trough is closed above by means of a plate, which has a high collar upon it to allow the stamp to pass through, and into this the water used in stamping is led. Besides this, there rests upon the plate a cast-iron hopper for feeding the ore through. On the front and back sides of the mortar are rectangular openings in a framework inclined forward, upon which are bolted large screens and especial receiving-troughs to catch the slime spurted through the screen, and conduct it through pipes underneath into the sluice.

The cylinder is supplied with an ordinary slide-valve, with upper and lower parts. The valve is worked by means of a pulley and belt from the driving-engine. But there are two elliptical cog-wheels interposed, which, on account of the irregularity of the motion arising therefrom, cut off the stem from the upper part more quickly than from the lower one.

At each steam-stamp, in addition to the workmen who have care of the feeding, there is a boy in attendance who regulates the steam supply-valve above, and, in case of any trouble in the operations, immediately shuts it and throws off the two driving-belts.

The connexion of the mortar with the two wooden principal posts of the stamp-frame, on the one side, and with the foundation of the latter on the other, as well as the foundation itself, are so made that the powerful blows of the heavy stamp produce only slight movements in the frame and scarcely

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* In this connexion is deserving of special notice the twin steam-hammer of T. W. Forbes of Philadelphia, which was also in the Exhibition, but yet, unfortunately, was set running only at a late day. In this machine two small steam-hammers with a rotating slide-valve in common are coupled together in an ingenious manner by providing the piston-rods with conical enlargements, by means of which two guiding levers of the rotating valve are turned hither and thither, so that one stamp always regulates the other. The weight of each stamp is 220 lbs., and the machine works in a very quick and pleasing manner. Unfortunately, within the time allotted to the business of awarding the prizes, experiments could not be made to test the machine's capacity for work.

noticeable tremblings in the building. The foundation consists of a number of layers of stout wooden beams placed crosswise upon one another, and the whole firmly fastened together by means of long upright anchor-bolts. The beams lie at a small distance from one other, giving room for the bolts between them, and the remaining space is filled with cement. Upon the top layer rest two parallel cast-iron sills, fastened by anchor-bolts to the foundation. The wooden sills of the frame rest upon two wooden cross-beams lying crosswise on the cast-iron sills, and to them the layers of timber are firmly bolted, whereby a certain elasticity is given to the frame itself. On the two iron sills rests a layer of spring beams, tongued on the ends; upon that a rubber plate, and on top of this a broad, thick iron plate, upon which is fastened the mortar, which has a hole in the middle of the bottom, through which an iron dowel-bolt passes. Between the posts of the frame there are upright projecting side-braces to the mortar, which are held sidewise only, between iron plates screwed to both sides of the posts; so that the mortar can work itself up and down against the posts, and the blows falling upon it are not transmitted directly to the frame.

The Ball stamping-hammer requires very little working room compared with other stamps of equal execution. Twenty feet square is enough for it, and of this the machine itself demands only 12½ to 15½ feet. According to the universal reports of the mine managers at Lake Superior, important repairs are extremely seldom required, and, as a rule, consist in replacing the stamps themselves, which last about eight years, or in boring out the cylinder, and the like. In the stamp mills of Austrian Hungary and Germany the removal of the pulp from the mortar has of late been promoted by damming up the slime in boxes bolted in front of the screens.* This so-called *stay-battery*,† (Stausatz) invented by Von Rittinger, aids essentially in the working of the mill and diminishes the dead-stamping.

The amount of water used for the stamps in such a mill, as stated by Von Rittinger, is 13 to 32 litres (3 to 8·5 gallons) for each stamp weighing 146 kilogrammes (260 Vienna pounds) and having 70 lifts of 184 millimetres (7 Vienna inches) per minute. Thus, in 24 hours, 1,344 kilogrammes (2,400 Vienna pounds) of quartzy ore are stamped through a screen of 1 millimetre mesh; and, consequently, 14 to 34 cubic metres (3,498 to 8,982 gallons) of water are used for 1,000 kilogrammes (2,205 pounds) of stamping ore.‡

The Ball machine at Lake Superior shows a water consumption of 30 cubic metres (7,925 gallons) to 1 ton of stamped ore.

According to Mr. G. F. Deetken, the California stamp-mills use, on the average, 0·5 cubic foot (14,160 cubic centimetres) per minute for each stamp. Since such a one stamps 2 tons of ore in 24 hours, it requires 20 cubic metres (5,282 gallons) of water to 1,000 kilogrammes of ore. The consumption of iron in the shoes and bottoms evidently varies very much with the hardness of the iron and the ore-gangue, and forms an important element of the running expenses. In the German light-stamp mills, which have cast-iron bottoms, there is, according to Gätzschmann, a wear on the shoe of about 0·8 kilogramme to 1,000 kilogrammes of hard ore, and on the bottoms, 0·1 to 0·4 kilogramme; or, together, 0·9 to 1·2 kilogramme. In the California mills, Deetken says, for each ton of ore stamped there is a consumption of iron amounting to 1¼ pounds on the shoe, and 0·6 pound on the bottom, or a total of $0·5 + 0·27 = 0·77$ kilogrammes of iron to 1,000 kilogrammes of ore.

In the Ball stamp the total consumption of iron is given at 0·08 to 0·50 kilogrammes to 1,000 kilogrammes of ore, according to the hardness of the same.

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* In the Ball stamp there is just such a contrivance.
† R. W. Raymond, *Mining Statistics, &c.*, 1870, p. 682.
‡ P. von Rittinger, *Lehrbuch der Aufbereitungskunde*, p. 142.

TABLE VI.—*Size and capacity of Stamp-mills.*

No.	Stamping System.	Locality.	Stamps in each Set.	Weight of Stamp.	Height of Lift.	Blows per Minute.	Working Force to lift one Stamp.	Ore crushed by one Stamp.	
								In 24 Working Hours.	With a Working Force of 1 Horse-power.
			No	Kilo.	Centi-metres	No.	Horse-power.	Kilos.	Kilos.
1	Ball's Steam Stamp, No. 1	Calumet&Hecla Mines, Lake Superior	1	2,041	71	90	30·0	124,300 (hard trap-conglomerate).	4,143
	Same, No. 2 -	Pewabic Mine, Lake Superior	1	1,588	71	90	22·5	ab.70,000 (same rock).	ab. 3,111
3	Same, No. 3 -	Ashland (Mass.) Emery Mills -	1	295	46	120	3·0	ab.12,000 (corundum).	ab. 4,000
4	Atmospheric Mill - -	Phœnix Mine, Lake Superior	6	ab.500	23 (?)	140	3·6 (?)	ab. 8,463 (trap-gangue).	ab. 2,250
5	CaliforniaStamp Mills - -	Grass Valley Mills - -	5	385	25	61	1·3	4,240	3,260
6	Carthinia Stamp Mills - - (With staying Sieve)*	Austrian Hungary - -	5	146	18·4	70	0·42	1,344 (quartzy gangue).	3,200

If we exclude the atmospheric mill, in which the stamp-lift is taken as equal to that of the moving-air piston, although in reality it must be smaller on account of the compression of the air, we get from the above table the astonishing result, that for one horse-power of the stamp-weight actually lifted, between 3,111 and 4,143 kilogrammes of rock are stamped, and that herein no difference worth mentioning exists between the capacity of the lightest stamp and the more than ten times as heavy stamp of Ball's machine, No. 2.

Besides this, the quartz-rocks at the lighter stamps, Nos. 5 and 6, and the corundum at No. 3 are essentially harder than that at the heaviest stamps, Nos. 1 and 2. It is also to be observed that the mesh of the screens at the lighter stamps is about 1 millimetre, while a much larger mesh is used with the heavy steam-stamps at Lake Superior for copper gangue.

We see, too, that the advantages of the heavy stamp are to be sought for only in the saving of room and running expense, and in a higher working capacity in consequence of diminished friction.

Therefore the choice of a stamp-weight depends solely upon the nature of the rock to be stamped. Otherwise, however that arrangement has the advantage which produces the very highest possible velocity of the stamp in order to arrive at the greatest possible working effect with the given weight of stamp.

V. CLEANSING AND SORTING MACHINES.

1. CLEANSING APPARATUS.—In the case of cleansing and sorting machines there are a few apparently rather simple mechanical problems to solve. Either a firm mineral grain, as spherosiderite, lenticular iron ore, brown iron ore, manganese ore, phosphorite, is to be cleared from the coating of sand, loam, and clay that surrounds it, without needing any further dressing,—in which very simple case cleansing is limited to merely soaking, scraping, and washing the sandy or tough mud from the inclosed mineral grains and pieces,—or the hard clean grains require a still further mechanical dressing, as in the case of alluvial deposits containing gold and tin ores or precious stones, the so-called "hydraulic diggings" (Seifenwerk), and as with the "smalls" in ore-mining. The cleansing apparatus, therefore, is connected

* Rittinger, *Aufbereitungskunde*, p. 142.

with that for sorting or sizing the grains, the one part for picking or "culling" (Klauben) the portable lumps of more than 2 to 3 cubic metres, the other part for preparing the smaller grains for the jigging and slime processes. Or, as in coal-mining, it only amounts to a separation of the coal brought out of the mine into different sorts according to size,—lump, furnace, nut, and range coals,—to break off the slate and rock attached to the lumps and cubes, and to subject these impure coals, as well as the screenings, to a further mechanical dressing.

While washing plays the chief part in the first-named case, in the second and third cases the cleansing operation stands, according to local conditions, more or less in the background. Where the local conditions present hinderances to the use of machinery, or where there is an abundant supply of water at hand, or easily brought in, as at iron mines and hydraulic diggings, it is often the custom still to make use of the simplest arrangements, such as have been employed from old times down to the present. The loamy minerals are put into a trough or sluice,—filter or rinsing-tub (Durchlass, Spülgraben),—and worked over with rakes in a continuous stream of water, until the mud and sand are scraped and washed off, and then they are broken up.

Hydraulic Mining.—During the last ten years, hydraulic mining has been carried on with considerable outlay of capital, in the enormous gold-bearing gravel-beds of California. From the initial operations begun at Yankee Jim, in Placer County in 1852, with primitive apparatus, this hydraulic mining has been developed into very considerable proportions; mountain ridges have been bored through, and valleys about a thousand feet deep have been spanned by iron pipes, in order to hurl huge masses of water in mighty streams against the gravel in the banks, and then to carry off the loosened gold-bearing material in wooden sluice-boxes of gigantic proportions, to be subjected next to a mechanical separation. In this operation the coarser quartz pebbles roll off sidewise out of the sluices and over the mountain slope, and then the gold gravel and sand are subjected to a further mechanical dressing, and finally the gold is extracted by amalgamation. These arrangements for cleansing and separating—sluice, sluice-box, undercurrent, grating, and grizzly—are exceedingly simple. Technical skill is shown chiefly in the construction of the outlets of the iron water-pipes, the so-called "hydraulic nozzles," as well as in the laying of enormous blasts, previous to the process of hydraulic extraction, for the purpose of loosening the bank of gold-gravel to be attacked. Without going further, in this place, into the particulars of this extraordinary mode of mining and dressing, we refer to an article on the subject by Mr. Charles Waldeyer, of Cherokee, Butte County, California, in Raymond's official mining statistics of the United States for the year 1873.*

At the gold mines in Siebenbürgen (Transylvania), and at the copper mines in Hesse, there existed, even in the middle of the last century, mechanical "agitators" for washing (Krählwäschen), provided with an upright spindle and horizontal rake-like arms, which worked in a shallow tub. At the Siberian gold-dressing works, and the iron mines in the neighbourhood of Stolberg, in Rhenish Prussia, such machines have been in use even very lately.

At iron-dressing works in France, mechanical hydraulic agitators (patouillets) have been set up, in which iron rakes distributed about a horizontal shaft stir up the stuff placed in a trough under water. Similar washing apparatus is in use at the Pennsylvania brown-iron mines. But the more practical method is to feed the stuff to be washed into movable vessels.

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* R. W. Raymond, *Mineral Resources of the United States west of the Rocky Mountains*, 1873, chap. xvii., p. 390. "This hydraulic gold-mining of California produces yearly from "10 to 12 millions of dollars in gold. The blasts are charged with 5 to 6 tons of powder. "The nozzles throw their streams of water to a distance of about 200 feet, with a velocity of "40 metres and a volume of 0·75 cubic metres per second. The Spring Valley Company "has laid across the valley of the West Branch of the American River an iron pipe of 30 "inches diameter and 14,000 feet long, which descends the slope of Yankee Hill a vertical "distance of 980 feet and ascends the opposite slope of Red Hill to a vertical distance of "830 feet."

The "cradle" of the gold-washer is a simple contrivance of this kind, which is used in California and Australia in various ways, in combination with amalgamation, in the washing of gold-bearing river alluvium. A trough, provided with a sieve for separating the coarse rolling pieces, forms the upper part of the California cradle, into which the stuff is introduced under a stream of water. Under it there is a second inclined trough provided with cross-pieces, in which the grains of gold are caught and amalgamated. During the filling the cradle is rocked to and fro. Revolving drums, into which the raw stuff is poured and stirred in a steady stream of water, have been used at ore mines since the beginning of the present century. They first received a practical form, however, about 30 years ago from Von Carnall, in the ore-dressing establishments at Tarnowitz, in Upper Silesia, and at Altenberg, near Aix-la-Chapelle, which, in their systematic disposition, formed, to a certain degree, the starting point of the more recent science of mechanical ore-dressing in Germany. The use of drums for refining and sorting has since been rapidly and generally adopted.

The cleansing drum was originally provided with a shaft, to the arms of which the plate-metal cover was fastened. This cover had, in the middle, an enlargement lined with prongs or long points, and at the outlet end a narrow cylinder sieve for separating the coarse picking-stuff from the fine jigging-stuff. The water for washing was introduced at the inlet with the ore.

Large cylindrical wash-drums were introduced about 20 years ago at the blast-furnaces at Hochdahl, near Düsseldorf, on the lower Rhine, for washing clayey iron ores. In those the easily-broken lancet-shaped points were replaced by durable, firmly riveted angle-bracket, which, in revolving, lifted the pieces of ore and then let them fall again. The cleansing-drums, built in 1862 for the immense ore-dressing establishment at Scharley, in Upper Silesia, to work up clayey zinc and lead ores, were modelled by Sievers & Co. (now the Humboldt Stock Company, at Kalk, near Cologne), and became the starting point of a series of genuine advances.*

These drums consist of a strong, horizontal, sheet-iron cylinder, closed at both ends by ring-shaped disks, and upon which two smoothly-turned cast-iron rims and a toothed rim are wedged. The rims each rest on three friction rollers, the middle one of which can be so arranged as to bear most of the weight. The drum revolves by means of a small driving-wheel connected with the toothed rim, and, though quite heavy, has no axle, but its weight is borne by the friction rollers, which have short axles resting upon a solid iron frame, similar to that on the rotating puddling oven of Danks and others. One of the ring-shaped discs, through which the raw stuff is introduced, is provided with a perforated flange of five millimetres mesh for carrying off the fine grains and slime. On the inside of the cylinder cover are riveted 24 strong angle-irons, eight centimetres broad, arranged in a spiral that makes a quarter revolution in its whole length. The drum is, therefore, in a certain degree, like a rifled cannon, whose grooves have a quarter turn. Furthermore, strong, iron, box-like scoops are riveted to the angle-irons at suitable distances near the outlet, which, at every revolution, take up and throw down the raw stuff, together with the water. By means of this arrangement the raw stuff introduced is shoved evenly towards the outlet end of the drum, and, at the same time, raised from the bottom and turned over by each angle-iron and scoop, while the purifying water admitted at the outlet end washes away the slime and fine mineral grains in the opposite direction. The washing thus takes place in a completely systematic and continuous manner, with a minimum of water. The two purifying-drums at Scharley are 4·7 metres long by 2·27 metres diameter. The last drum set up has 192 scoops, makes nine revolutions per minute, and works up 250 cubic metres of clayey raw material in 24 hours. A drum with its frame costs 15,483 marks, and weighs altogether 19,031 kilogrammes.

The cleansing of the small stuff obtained from the ore-gangue is limited generally to a mere washing off of the pieces of mineral, and is effected in a short division of the sorting-drum.

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* Schönfelder, *Die baulichen Anlagen auf den Berg-, Hütten-, und Salinenwerken in Preussen.* (Supplement to the *Zeitschrift f. d. Berg-, Hütten-, und Salinenwesen i. d. Preuss. St.*, 3 *Jahrgang.*) Press of Director Kunitz, at Scharley, p. 22, Plate IV.

The English method of purification can still be recommended in small mining establishments where ore-dressing is conducted in the simplest manner possible. In this process the raw material from the mine is dumped into a funnel made of stone, about 0·5 metre deep, and open at at one side, and therein washed by a falling stream of water. At the bottom of the funnel is an iron grate let into a wooden table, through which the jigging-stuff is washed into a draining-pit. Two powerful workmen stand upon the table, who clean the raw stuff with iron scrapers, under the stream of water, and shove it to the picking boys who stand around the table. The jigging-stuff is shovelled out of the draining-pit to the adjacent hand-jig, and upon this is sorted and separated at the same time.

Such purifying funnels were introduced from England into Rhenish lead and zinc ore-dressing establishments nearly 30 years ago. Such a funnel works up about 40 or 50 metrical tons of small stuff, unmixed with clay, in 9 or 10 hours.

2. Sorting-Machines. *a, Ore-Dressing.* — In the second half of the previous century numerous mechanical contrivances were employed for sorting ores, in which slightly inclined grates or sieves, successively increasing in width, were placed one after the other, or, with their width diminishing in succession, were placed under one another.

These screens (Rätter) were either stationary, and then needed special workmen to scrape the stuff through them, or they were movable, so that the stuff was forwarded automatically either by shaking, by counter-thrust, or by an upward blow. The simple stationary screens have of late been used only for coarse sorting work at coal mines (described above). The shaking or percussion screens are occasionally employed for special purposes at ore mines, but generally the cylindrical or conical-shaped rotating drum-sieve is used for the sorting of ore-stuff.* For forwarding the granular stuff along the revolving surface of the sieve a slight inclination is given to the axle of the drum. With conical ones the inclination given to the sides of the drum is sufficient.

It is interesting to observe in what wonderful ways technology has, by numerous complications, striven to make the working of the sorting-drums more efficient, and then, quite lately, has arrived at a very simple solution of the problem, near the starting point.

Afterwards, according to the statement of Commissioner Holzberg, of Kupferberg, in Lower Silesia, drum-sieves were introduced at the Freiberg mines in 1792, but after a few years were again rejected† on account of their impracticable arrangements. According to Stütz the cylindrical sorting-drums were invented in a serviceable form, and brought into public use, ostensibly by Ursz, master carpenter of the works at Nagyag, in Transylvania, in the beginning of the nineteenth century. This sorting-drum formed the continuation of a conical cleansing-drum, made of wooden staves, in the shape of a barrel, with inclined axis, and consisting of four cylindrical wire sieves of successively increasing width and length and decreasing mesh. The sorting took place in such a manner that the first sieve division carried forward the coarser sorts to the division, and only let the finest sort pass through with the slime, while the coarser sorts, with increasing size of grain, fell through the next sieves, and finally the coarsest kind of grain came out at the end after passing over sieve. This apparatus, in spite of its astonishing result in working up 810 centners of ore in 12 hours, received so little circulation and confidence in the first 10 years, that even Karsten, as late as 1831, pronounced its working incomplete, and the apparatus, on account of the high cost of maintenance, of little advantage. After the grate-shaped cleansing-drums, working in water, and serving at the same time as sorting-drums, had already been employed in France, the drum-sieve, soon after 1840, was taken up again at the German mines, and, as it appears, so improved in its construction, especially at the Friedrich Mine, near Tarnowitz, that its use has spread very rapidly since that time.

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* The use of six or eight-sided, prismatic or truncated, pyramidal drums, formerly very common, has been little employed of late.

† Karsten, *System der Metallurgie*, ii., p. 89, and Gätzschmann, *Aufbereitung*, i., p. 674.

In the next place the sieves and drums were made stationary and of uniform diameter in the separate sieve-divisions. The first division was arranged with so wide a mesh that all the finer stuff was immediately separated from the coarser and conducted to a second finer mesh-drum, which was lying in a trough filled with water. In the first drum, according to the original system, a series of sorts was formed, with grains increasing in size from 0·5 to 3 centimetres, and besides, to lighten the labour, a spray of water was introduced into the drum; in the second or finer drum, was sorted in a similar manner, first, the tailings, with the slime and sand, and then the finer jigging grains of 1·5 to 5 millimetres diameter. An inconvenience arose, however, from the fact that the sieves were very long and that the coarsest grains, which caused most wear, passed over the finer sieve-divisions through the whole length of the drum.

Max Braun, the well-known former chief engineer of the Altenberg Company, sought to remedy this difficulty by his combination, concentric, conical drum-sieve. The difficulty with this was, that the diameter of the outer sieve for the finer grains was considerably larger than that of the inner sieve, which kept back the coarser grains, and that the closeness of the sizing suffered from this disproportion.

b. Coal-Dressing.—The screens (Rätter), seldom employed in ore-dressing, came into widely-extended use, with the magnificent development of coal-mining, first in England, then in Europe, as well as at the anthracite mines of Pennsylvania. The object here is to sort masses of large pieces into a few sizes rather than to carry out a minute process, as in ore-dressing. Working capacity, durability, and simplicity have therefore been chiefly considered in coal-screening establishments. As a rule, as many iron screens (Stängelsiebe), of increasing width, lie under one another on a long inclined slope as there are sizes to be made. The principal contrivances to be considered in this connexion are chiefly those for raising and precipitating the coal automatically as it comes from the mine, together with those for receiving and loading the sorted coal. Such arrangements are especially developed in Pennsylvania. Briart's screen with rotating bar-gates, at the Mariemont and Bascoup Mines, in Hainaut, may be called a decided improvement.* The grating of the screen is slightly inclined in order to diminish the breaking of the pieces of coal, and is composed of alternating stationary and movable iron bars. The movable screen-bars rest on an iron frame, whose lower end is borne by two swinging supports, and whose upper end is moved by two eccentrics on the same shaft. In this way the movable screen-bars are above the stationary ones during one-half of the revolution and below them during the other. By revolution is meant that the movable bars, in their upper position, push towards the lower end of the screen. The coal lying on the screen is raised intermittently and shoved gently downward, while, at the same time, the finer stuff has a chance to fall through the screen without being carried along by the coarser pieces. Aristide Bérard, the French engineer, a high authority in coal-dressing matters, in place of drums for sorting screenings, preferred a percussion-screen, arranged in a similar manner to a percussion-table, with several perforated iron plates of decreasing mesh fastened in a frame parallel to and under one another. The rebound was, besides, diminished by the use of rubber buffers. The thrust, inclination, and velocity must be in proper proportion. Bérard with a screen of this kind 1·25 metres broad, 2 metres long, inclined in the ratio of 1 : 10, and with a velocity of 160–170 strokes per minute, obtained a very good sizing of 15–18 tons of screenings per hour in three sorts.† With a smaller velocity the forward movement of the mass on the surface of the sieve diminishes at such a rate that, with about 100 strokes per minute, it would cease entirely. As only a few sorts are required in coal-dressing the percussion screens are all the more suitable, because, with a simpler and cheaper arrangement, they require less room and head of water than sorting-drums.

Sorting-drums are generally no longer used for the separation of coal, and even for the sorting of the smaller coal into "dice," "nut," "range,"

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* *Engineering*, January 1873.

† Bérard, *Épuration de la houille*, *Annales des Mines*, 5e sér. 1856, tome ix., pp. 147, 157. Plates V. and VI.

and "screenings" are used only where these are to be cleaned for use in coking.

The arrangement of the drums varies little in construction from the sorting-drums used in ore-dressing. The fewer grades required in the jigging of coal, especially of the smaller sorts, allows a decided simplification of the disposition of the drum system; on the other hand, as a rule, the great volume of stuff to be handled in coal-dressing requires a large diameter of drum.*

Local circumstances, in regard to the quality of the coal, its greater or less degree of hardness, intermixture with friable, foaming, ashy brown-coal, the character of the bituminous and clay slates which lie over and under the coal strata, require special variations in the disposition of the sorting machines. The extremely hard and, in itself, pure anthracite of Pennsylvania is sometimes intermixed with rather hard, thin strata of clay slate. In breaking up the coarser intermixed pieces the layers of clay slate are detached and a mixture of rounded fragments of anthracite and thin pieces of slate is produced. In order to separate the latter mechanically from the anthracite during the sizing the stuff, after sorting out the pieces of anthracite of about nut size, is conducted into a sorting-drum, with short compartments extending across the greater diameter of the drum, and these are provided with long, slit-like sieve-holes placed at right angles to the axis of the drum. The thin pieces of slate, in falling into these wide compartments, stand up on edge and slip through the narrow slits in the sieves, while the rounded pieces of anthracite roll over them.

Where the coal is not intermixed with ashy parts, but sharply separated layers of bituminous and clay slate form the impurities of the screenings, the latter are generally only washed without being ground. The sorting can then be limited to the separation of the picking-stuff. The earlier, careful sizing has of late been considered unnecessary, and even injudicious in such cases; since the old English method of bed-jigging has been profitably used in the continuous process.

If the coal is thoroughly intermixed with thin, ashy layers, then the screenings are sorted into picking-stuff, the size of the first into nut-coal, and into coal-dust. The impure, picked pieces and the nut-coal are broken up, then mixed with the coal-dust and brought to the jigging process.

In the case of quite brittle coals from veins with firm hanging and foot-walls, as the Liège and English caking coals, the proportion of ash in the sifted coal-dust is sometimes less than in the nut and egg-coals. Only the latter kinds are then washed clean and afterwards mixed with the unwashed coal-dust.

But even in such cases as the first mentioned, the attempt to wash the very fine slimy coal-dust has been abandoned until very recently, partly because the proper apparatus was wanting for removing the portion rich in ash, partly because drying it was too intricate. The very finest coal-slime was merely caught in large sumps and then either used at the mine for heating the boiler or thrown away as useless, as in England and Pennsylvania, and very often also in Upper Silesia.

3. Sorting of Fine Stuff by means of a Stream of Water.—The arrangements for sorting the fine sandy and slimy mineral products no longer capable of classification by sieves, and the grains which, in the case of ores, had a diameter of less than 1 to 2 millimetres, or in that of coal, less than 5 to 6 millimetres, by means of a stream of water, have already been thoroughly discussed in the theoretical chapter. The sand and slime troughs and sumps formerly in use have been almost universally supplanted during the last 20 years by the pointed-box and trough.

The cylindrical apparatus, with an upright ascending stream of water, which at that time came more into use for sorting, has lately been given up again on account of its large consumption of water.

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* In Germany the following sorts are customary: first, lump-coal, from a bar-screen of 90 millimetres mesh; second, cube-coal, from round-hole sieves of 60 millimetres mesh; third, coarse nut-coal, from 30 millimetres mesh, round-hole sieves; fourth, fine nut-coal, from 6 millimetres mesh, round-hole sieves; and finally, coal-dust.

The pointed-trough and pointed-box have, however, been provided with a supply of clear water above the outlet, and the principles of the horizontal and vertical streams of water have been conbined in such a manner that the supply of clear water was always in the narrow, lowest part of the wedge-shaped trough or pointed-box, and by this means only a little clear water was used. The amount of this water was so regulated that only a small surplus ascended to hinder the exit of the finer sands and slimes through the narrow outlet. The coarser sorted sand, suspended in clear water, was then carried off through this opening. At the same time it is important for the further continuous concentration process, that the sand carried out should form a thick, liquid slime, suspended in as little water as possible.

The troublesome heaping up of fine sand in the pointed-box, which was held back by the ascending stream of water and not carried forward by the horizontal one, was obviated simply by increasing or diminishing the ascending stream of water from time to time, or by hastening the flow at the outlet. As already mentioned, the water-stream apparatus, besides sizing, concentrated the minerals according to their specific gravities. Thus they formed, in a certain degree, a transition between the sorting-apparatus and the concentrating contrivances, which are to be discussed farther on.

Draining and Purifying-Apparatus for Sands and Slimes.—In ore-dressing the finest slimes which flow over the last and largest pointed-box contain generally so small a quantity of ore particles, that a further dressing no longer pays. On account of this soiling of the current of water it is seldom allowed to escape, but is conducted to the settling-pits or reservoirs for further clearing. In some of such settling-places there is maintained an intermittent flow in and out, so that, at times, the slime comes to a standstill; in others a continuous working system of numerous, shallow, rectangular sumps is so arranged that the stream of slime, divided into several branches, goes in and out through the whole breadth of the sump, with a velocity diminished as evenly as possible. The inlet and outlet canals to the sumps are then so arranged that each sump can be treated separately in emptying the slime deposited in it. The still muddy wash-water, overflowing from the settling sumps, is generally, to avoid trouble, again raised and conducted back to the dressing department.

In coal-dressing the finest and lightest portion, carried away with the wash-water, forms a valuable material, and dressing experts have been very busy with the collecting and drying of it, especially since it has been found that even the very fine coal-slime which floats in the stream of water can be separated by the jigging process from the sand particles, which are rich in ash, and a product can be obtained sufficiently poor in ash for making coke. Settling-sumps dug in the earth, and alternately filled and emptied, were more commonly used for this purpose in the old style of coal-washing than in ore-dressing. In the newer coal washing establishments of Germany, several rectangular revervoirs of masonry, in rows near each other, were so arranged on the ground, under cover, that the bottom of the reservoir should lie on a level with the railroad leading to the coke ovens, or to the loading places, so as to be able as quickly and as easily as possible, to load and carry off in cars the washed and dried refuse coal stored in the reservoirs. These latter are for this purpose open on the delivery-side to admit the cars. The delivery openings are closed by wooden planks set on edge, one above another, and held in place by suitable grooves in the side walls, as in a sluice. The masonry reservoirs are provided with a system of flooding-troughs and covered canals. While one reservoir is filled and others are draining some already dry are emptied. These reservoirs require considerable outlay. They are, therefore, generally used only for fine coal-dust, which cannot be held back and dried on the flat inclined, or the drum-shaped sieves, made of perforated iron, in which case only a comparatively small portion would need to be precipitated in the drying reservoir.

Herein certain practical inconveniences arise. To obtain a uniform product in coking or agglomerating the washed coal, the nut-coal, prevented by sifting from precipitation in the sumps, must be made sufficiently small, and again mixed with the coal-dust taken from the sumps. An irregular precipitation of the granular and slimy particles of coal takes place in the sump itself.

The coal-scum accumulating in certain places is especially troublesome; it consists chiefly of lignite, rich in ash, and consequently gives some lots of bad looking, poor coke.

Since September 1876, a coal and slate-draining apparatus, patented by the civil engineers, Riehn, Meinicke, and Wolf, at Görlitz, has been used at Pilsen, in Bohemia, for the dressing of coal for coking with the best results, and the difficult question of coal drainage appears to be solved by it in a happy manner. The apparatus resembles a continuous jigger in arrangement. The drainage takes place on a hair sieve, with a mesh 0·25 millimetre wide, which is protected against wear by a strong wide mesh metal webbing, and both are fastened to a wooden frame. These sieve-frames can be changed by removing them sidewise from the sifting-machines, which are provided for this purpose, with special easily closed split openings. The coal dust to be dried is conducted to the apparatus in a trough, in the condition of a thin liquid slime. After drying, the coal-dust falls continuously, either directly into a forwarding car or into the hopper of a grinding-mill. The water from the coal-slime on the sieve flows off continuously through several narrow pipes placed in the bottom of the sieve-box. The outflow is regulated by opening or shutting single pipes.

Such an apparatus, occupying a space only 2 metres wide by 4 metres long, needs 3 horse-power to drive it, and dries 10 tons of coal-grit per hour, so that it can be unloaded directly into the coke-ovens.

The loss of slime-coal in the water passing through the fine mesh of the hair sieve is very small. The hair sieves need to be changed very seldom, and often last several months.* The total cost of grease and sieves is said to be only 0·6 mark per 100 tons.

The total cost of drying appears, accordingly, so insignificant that it exerts scarcely any influence on the price of the product.† In Pilsen it has been customary for some time for the coal washed upon the coarse jigs, after being ground fine on a disintegrator (Schleudermühle), to be carried by a strong stream of water to the draining and drying apparatus. The washed and dried coal is elevated into a moderately large storage tower, divided into several compartments, which is recommended, in order to keep it from being disturbed by the continuous process going on in the works.

VI. Concentrators.

1. Hydraulic Jiggers.—The jigger, in its original form, consisted of a wide-meshed wire sieve, furnished with two handles, and this, when filled with a supply of unsorted mineral grains, was dipped into a tub filled with water and shaken by hand, partly with a revolving partly with an up-and-down motion. To empty the sieve, it was hung up by handles, with cords or small chains, to a long, wooden balance pole fastened at its thick end. In the Sardinian lead and zinc mines similar jigs are still in use, in competition with completely arranged modern jigs. The motion mentioned is produced by the workman drawing together the two cords on which the sieve hangs, and then letting them go, so that they give a twisting and an up-and-down rocking motion to the sieve.‡

In the English jig, the oblong sieve-frame, above 45 centimetres broad by 85 centimetres long, is provided with a woven sieve bottom, and is suspended, by means of two lateral, adjustable iron stirrups and hanging-bars, to two short arms of a strong, horizontal wooden shaft above it, provided with a

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* As the holders of the patent are about to obtain a patent right for the United States of America, the author must at present refrain from making public, in this place, the drawings and description of details, freely and voluntarily given him by the inventor.

† The Belgian department of the Paris Exposition of 1867 contained a centrifugal machine by Prosper Kanzer, under the name "Essoreuse," with a continuous feed and discharge, which was said to dry 5 tons of coal-dust per hour, and which had a diameter of 80 centimetres, and a velocity of 300 revolutions per minute. The use of this principle appears, however, not to have advanced beyond the experimental stage.

The centrifugal machines used for drying sugar, and in isolated cases for salt, do not work continuously. In drying fine-grained salt by means of centrifugal machines, the cost per ton (1,000 kilogrammes) of dried salt is about 2 marks,—a price too high for a product of such low value as coal.

‡ A. Habets, *Préparation mécanique*, p. 630.

long spring beam, and it moves in a spacious wooden cistern, which can hold several tons of fine ore. Motion is given to the sieve, after immersion in the water, by a boy, called a "jigger," who hangs with outstretched arms at the end of the long lever, and springs up and down on his toes.

A strong workman, with shovel and tray, does the filling and removing of the jigging-stuff. The gradual concentration which goes on by repeated operations upon a granular bed of ore spread out on the sieve, and in which, at the same time, the coarser mineral grains are sifted from the finer granular ore, has been thoroughly discussed in the theoretical section. The advantages, there shown, of this treatment, in comparison with the earlier German methods of jigging, find confirmation in the careful comparative experiments carried out at the Breinigerberg Mine, near Aix-la-Chapelle, which Habets gives in his above-mentioned report upon the Exposition at Paris, in 1867. According to him, well-authenticated docimastic assays showed that the losses in ore-dressing by the English and German methods were as follows: in zinc 4·03 as opposed to 9·91 per cent.; in lead 5·81 to 30·54 per cent.; in silver 27·85 to 40·17 per cent.; and generally, in dry weight, 7·5 against 14·40 per cent.; while the total loss of dressed products, in comparison with the raw ore, was: in zinc 43·20 to 43·45 per cent; in lead 33·61 to 56·66 per cent.; in silver 61·65 to 71·63 per cent.; and in dry weight 56·98 to 63·14 per cent. The cost of dressing is pretty much the same by both methods.*

In ore-dressing in Germany and in Austrian Hungary, they try to avoid the repeated operations occurring in the process of jigging into the lower tub by means of a previous sizing of the jigging-stuff, and by the strongest possible effect of the water-thrust upon narrow-meshed sieves.

In the effort to employ the cheap labour of children or women for the separation of the layers concentrated on the sieve according to specific gravity, they have, since the end of the previous century, attempted to effect the thrust in the jigging process by machinery, without, however, with the clumsy construction used, attaining any important advantage over hand-motion with the lever.

The stationary jig, with laterally applied hydraulic piston, as distinguished from the percussion or hydraulic jigger, was first used, according to Gätzschmann, in 1828, by Tutscnack, mine superintendent at Arany Idka, near Schmölnitz, in Hungary. A little later, in 1832, similar experiments were made by Petherick at the Cornish mines, and in 1833 by A. Bérard, at the mines *de l'argentière* (Hautes Alpes), which were imitated no further, but at the last place were attended with favourable results, without any knowledge of the Hungarian experiments. The arrangements were at that time defective, and therefore the success of the invention was for a long time doubtful, even in the experiments which were begun, about 1838, at the Saxon mines, at Freiberg, and at the Upper Hartz mines, at Andreasberg. Bérard, whose name is so closely connected with the further perfection of the jig, designated Dr. von Carnall, then a mining captain but afterwards superintendent, as the real inventor of the hydraulic jigger; because he succeeded, in the year 1840, in bringing it into permanent use by an efficient arrangement at the lead mine, Friedrich, near Tarnowitz.

In the Carnall jig, a piston moved by hand worked alternately upon two sieves. According to Bérard, a similar jig was soon afterwards introduced into the lead mine at Poullaouen, in Brittany.†

The efficient arrangements introduced by Carnall into ore-dressing in Upper Silesia, as well as into the extensive zinc-washer, constructed in accordance with his plans, at the Altenberg Mine, near Aix-la-Chapelle, and which, to its advantage, attracted the attention of other foreign authors‡ also, on account of its saving of wages, caused a rapidly-spread use of the hydraulic jig from that time. The first successful and permanent use of this machine for coal-dressing was at the mines at Potschappel, near Dresden, in the same year, 1840.

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* A. Habets, *Préparation mécanique*, p. 628.

† Aristide Bérard, *Epuration de la houille, Annales des Mines*, 4e sér., 1856, tome ix., p. 150.

‡ Achille Delasse, *De la calamine et de la galène dans la haute Silésie, Annales des Mines*, 4e sér., 1843, tome iv., p. 377.

The hydraulic jigs had frames nearly square set in them, about 0·25 to 0·33 square metre in size, in which, generally narrow wire-rod screens were held between strong cross pieces. This form was used, except in England, even in the percussion-jig, by letting the sieve frame-work like a piston in a narrow, inclosed box.

To prevent the uneven working of the water upon the surface of the sieve, and the spaces above and below were united by lateral canals, to diminish the disadvantageous back-flow of the water through the sieve-holes. Finally, the piston-jugs were provided with suction and force-valves; the former of which led from the space over the sieve to the piston-chamber; the latter from there to the water-chamber under the sieve. This system, specially recommended by Rittinger, was used by him, and later by Dr. M. F. Stapff, in Sweden, in hydraulic machines with under-pistons, to which the force-valve was then applied.*

Recently a double jig, invented by Kasalowsky, has been much used. In it the piston moves horizontally in a rectangular opening in the partition-wall, which divides the two jig-boxes; while one end of the piston-rod, carried outside through a stuffing-box, is coupled to the driving-shaft, the other goes straight into the opposite side of the box.

All these various, somewhat costly, and complicated contrivances for ore-dressing scarcely produced a further advance in the jigging process worthy of notice.

The hydraulic jigger first obtained importance in ore-dressing by means of a *continuous jigging process*, while mechanical contrivances were used to constantly carry into different receptacles the mineral grains, separated upon the sieve in layers by specific gravity, without interrupting the jigging process, or at all disturbing the separation of the layers already completed, as happens in the ordinary jigging process in removing the layers by hand.

The great merit of this improvement is due to M. Aristide Bérard, previously mentioned,† who, in the year 1848, used the continuous removal in his hydraulic jig for washing coal, which was also distinguished for its excellent construction. The success of his model coal-washing apparatus was so decided that it spread rapidly from Anzin, in France, over Belgium, Germany, and Great Britain, and experiments were made in the same direction, in ore-dressing, by Vogl, smelting-master at Joachimstal, in Bohemia, in 1849, and by Fritz Wimmer, in the Hartz Mountains, in 1850.‡

The whole apparatus is lightly and durably made of cast and wrought-iron, of the proper proportions for the cheap working up of material. The round jig-piston works in a bored cylinder, while the pipe for supplying the clear water opens under the piston; so that the set-back of the water upon the sieve is diminished by the inward stroke of the piston during the suction, and the slime is kept as far as possible from the piston. The flow of the water from the pipe is hindered, in the descent of the piston, by the increased pressure under it. The same success is obtained, in this simple way, without valves, as in Rittinger's and Stapff's jig-pump (Setzpumpe) with suction and force-valves. The box under the jig-sieve is so formed as to distribute the hydraulic thrust properly on the sieve, as well as to catch the fine, specifically-heavier stuff (Fassvorrath) in a hollow in the bottom, and to let it off, from time to time, through an opening. The coarser "deads," which collect on the sieve, are carried away continuously, with a comparatively small quantity of water, by a simple, easily-accessible and regulated contrivance, which is a model to this day. The upper lighter layer is, at the same time, held back by a stopping-bar, which reaches across the sieve and is raised somewhat from the bottom; while the specifically-heavier stuff of the lowest layer, passing under the bar, must rise behind it, over a low wall which stands on the bottom and has a horizontal overfall edge, before it can reach the outlet pipe. The coal, previously sorted into three or four sizes upon a narrow percussion-

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* R. W. Raymond, *Mining Statistics*, 1873, p. 434.

† Bérard, *Annales des Mines*, 6e sér., 1856, tome ix., p. 150. The excellent drawings, Plates V., VI., and VII. attached, give all the details of construction.

‡ At that time director of the Rammelsberg Mine, near Goslar, and associate editor of the *Berg und Hüttenmännische Zeitung*. Professor Gätzschmann in his text-book (ii., p. 95), confuses him with an inspector of stamping of the same name.

screen, enters the jig in a strong stream of water, immediately behind the stopping-bar.

The removal of the specifically-light coal forming the upper layer on the sieve, takes place at the other end, over the edge of the jig-box, made somewhat lower at that point, so that the water, overflowing at each lift, carries the pieces of coal with it.

Then follows the drying of the wet coal in various ways, according to the quantity of the coal-slime, either simply by passing it over a finely-perforated metal plate, slightly curved downward, directly into the forwarding car, or into a discharge-box made expressly for purifying the coal-slime, out of which the water is drawn off through a syphon-shaped slit at one end, and at the other, the coal is carried over the edge, somewhat raised at that point, by a flat broad elevator, and thereby dried at the same time.

Bérard's arrangement for moving the piston, even to this day, remains the model, and so much so, that it has been returned to again after many and long-continued trials of differing systems. This suspension of the piston-rod to a shaft with a short crank, which works in a similar manner to the complicated eccentric motion so prevalent at the present time, seems very simple. By this means, Bérard got about 100 short lifts per minute. His application of Fairbairn's crank-side link* is more complicated, yet for the preparation of coarse-grained jigging-stuff is more efficient. This transmission of a crank motion by means of a movable slide-block in a slot to the short arm of the link connected with the piston gives almost double the velocity for the down-stroke that it does for the up-stroke.

Bérard found that he obtained the same effect with 75 strokes of the crank-slide as with 100 strokes of the common crank. He further recommends, in this case, making the connexion of the piston with the piston-rod elastic by means of india-rubber discs laid between them above and below, in order to lessen the too heavy shock of the piston on the water-column in the rapid descent. This hint deserves especial attention on account of the quite rapid wear of the Fairbairn link.

At the ore-dressing establishment of the Pfingstwiese Mine, near Ems, on the Lahn, Province of Hesse-Nassau, the principle, carried out for sixty years, of a slow ascent and rapid descent of the jig-piston with a uniform revolution of the transmission shaft by means of a lever connexion, has also been used elsewhere with great success, on account of its greater simplicity and durability.

A similar mechanism has been brought into use by Detombaij and Scheuren in their jig.†

Bérard gave to the cylindrical piston a diameter of 60 centimetres or 0·2827 square metres surface, to the jig-sieves 1·6 square metres, therefore a greater surface in the proportion of 1 : 5·66; he, consequently, obtained with with a piston-stroke of 10 centimetres a lift of 1·76 centimetres above the sieve.

A Bérard coal-washer—consisting of three jigs, side by side, with the accompanying roll-crusher, elevator, sorting-screens, and a pump for raising the water again—requires an engine of about 10 horse-power, and washes 150 tons of coal in 10 hours.

Upon this hypothesis Bérard (in another place) reckons the total cost of washing from 0·28 to at most 0·50 francs per ton, and the yearly profit of such an establishment, in comparison with the primitive washing by hand formerly in general use, at from 86,000 to 93,000 francs a year. In estimating Bérard's services as founder of a rational process of dressing coal, it must not be forgotten that the use of coke for the production of the best pig-iron depends upon the dimunition of the large percentage of ash in coal, which was first rendered possible by means of cheap coal-washing; also that, in France, for instance, the successful competition of the native coal with the Welsh coal

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* This mechanism was introduced into Germany for the dressing of ore at the Altenberg Zinc Mine, near Aix-la-Chapelle, by the well-known civil engineer Carl Kley, of Bonn, and is therefore generally called Kley's crank-slide. In France it has received a still further development from Huet & Geyler, of Paris, so that the link is placed not in the same position as the piston-rod lever, but at a decided angle to it, in order to produce a pause after the rapid descent of the piston.—A. Habets, *Préparation mécanique*, p. 592, and Plate VIII.

† A. Habets, *Préparation mécanique*, p. 593, Plate VIII., Figures 8 and 9.

for marine purposes is made possible solely through careful dressing and agglomeration.

The difficult problem of both cleaning and drying the very fine coal-dust, often occurring as tough slime, and largely mixed with sand and clay, has only very recently been solved in a satisfactory manner.

The new coal-jigs for coarse grained stuff, made by Meynier, Rexroth, Sievers & Co., Huet & Geyler, and others, do not appear to excel the elder one of Bérard in the general arrangement, nor in the details of construction, nor in execution.*

Continuous-Jigs for Fine and Coarse-grained Ores.

While in coal-dressing the continuous-jig for coarse-grained stuff effected only a separation into two sorts, clean-washed coal and waste, in ore-dressing, on the contrary, the effort has been to obtain with such machines —varying with the nature of the ore to be treated—several other sorts, between the barren waste and the pure ore, which is specifically the heaviest, either in order to reduce these middle products still further, especially through separation by stamping or rolling, or that the specifically lighter ores, such as blende and iron pyrites, may be separated directly.

The first continuously-working machines of Vogt and Fritz Wimmer, above-mentioned, had, according to Gätzschmann, moveable-jig sieves in a jig-box. The complicated delivery contrivances of Vogt seemed to have hindered the introduction of the delivery of several sorts on the same sieve which was tried by him. The experiments made by Rittinger, at Przibram, in the year 1851, to solve the problem by means of a jig-sieve moved in a horizontal direction by blows (the percussion-jig), were not satisfactory.

At the same time, F. Wimmer, at Clausthal, as the author remembers from personal inspection, adopted the principle, which is the standard to-day, of placing several piston-jigs one behind another, separated from each other by low overfall division walls, and of carrying off the specifically heavier kinds of ore, which settle upon the bottom of each sieve, through special pipes provided with ring-shaped sluice-boards, at their upper outlets, but removing the "deads" over a notched edge at the end of the last jig.

The delivery through ring-sluices, acting like siphons, coincides in principle with Bérard's jig-sieve.

The experiments continued at the Hülfe-Gottes and Bergwerk-wohlfahrt Mines, in the Hartz, had still many difficulties to overcome, so that the first Clausthal coarse-grain jig that actually worked automatically came into use in 1861, at the Dorothea ore-dressing establishment.†

At the Silberau Mine, near Ems,‡ they have supplied the place of the downcast discharge-pipe with the ring-sluice by a narrow pipe first led upward from the jig-box and over the edge, and then bent downward, and provided with two cocks, in order to be able to regulate the discharge at will and use as little water as possible.

At the Bleiberg-ès-Montzen Mine, in Belgium, they lay several slit-shaped, siphon-like outlet-canals in steps, one behind another, at the end of the jig-sieve,§ in order to obtain besides the deads two other concentrated middle products which need still further dressing.

The complete solution of the difficulties of continuous-jigging, and at the same time the most important advance in dressing the fine sand-like stuff, hitherto so expensive and entailing the greatest loss of ore, was attained by the use of the English bed-jigging process with the continuous-jig, at Clausthal, in the Hartz, and was even used for the before-mentioned sands, which hitherto had been treated in slime-pits, on round buddles and percussion-tables. A complete revolution in ore-dressing, thus rendered possible, has since been brought about through the almost entire rejection in many ore-dressing processes of the slow, costly, and wasteful buddle-washing, and at the same time a simpler and more effective apparatus has been obtained

* M. A. Pernolet, *Notes sur la préparation mécanique et la carbonisation de la houille, Ann. des Mines*, 7e sér., 1872, tome ii., p. 115; A. Habets, *Préparation mécanique*.

† Gätzschmann, *Die Aufbereitung*, p. 112; *Berg- und Hüttenmannische Zeitung*, 1853, pp. 643, 649; 1874, p. 400; R. W. Raymond, *Statistics of Mines and Mining*, 1873, p. 439.

‡ *Revue universelle des Mines*, 1866, tome xx., p. 28, and Habets, *Préparation mécanique* p. 595.

§ A. Habets, *Préparation mécanique*, p. 600.

for the dressing of fine coal-dust. The discharge into the under-tub through a bed of ore-grains, spread out on a wide-meshed but stationary sieve, can now take place continuously with each stroke of the piston, in the simplest manner, without loss of water, exactly as in the old English tossing-keeve. The number of jigs together in a row permits the successive delivery of an equal number of grain-sorts of progressively diminishing specific gravity. The material proceeds from one sieve to another over a very low overfall partition without hindering the depositing in layers, according to specific gravity, which is effected by passing over the surface of the first sieve. The deads carried over the edge of the last sieve can take with them into the waste only a very small portion of ore, in the form of very fine scales floating in water. It is still possible to retain a considerable portion of these finest ore-particles upon plane-tables over which the tailings are led.*

Through the previous careful sorting of the jigging-stuff, according to size of grain, by means of sorting-sieves, and for the finest stuff, by means of slime-separators, pointed troughs, or the so-called "classificators," a definite quantity of ore can be fed to each sieve system, and the proper height of lift and velocity of piston-stroke be given to each system. By diminishing the height of lift to a few millimetres, and increasing the number of strokes to about 150 per minute, it is still possible to manipulate satisfactorily meal as fine as 0·5 millimetres.

The jig-box contains, under the piston and sieve, a separate space, either pointed on the bottom or, better still, cask-shaped for each division, and the deepest point lies directly under the partition-wall between the sieve and piston frames.

A vertical draw-rod going to the deepest point of the jig-box and provided with a hand-lever, can therefore be placed in this partition-wall; and a cast-iron conically-turned stopper at its lower end fits tight into a turned cast-iron discharge-pipe, in order, from time to time, to quickly let off the concentrated stuff into a storage box placed under the partition, without disturbing the jigging process.

In this way the greatest simplicity in construction and management is combined with a reasonable mode of operation, and the earlier deficiencies of the German jigging process have been removed by the adoption of the efficient fundamental principle of the English practice, without being subject to the evils of the latter, arising from hand-labour and frequent repetition of processes.

At the Paris Exposition of 1867, where were exhibited the plans of the very large, new, central dressing-works at Clausthal, in which these leading principles have been realized, a favourable opportunity was afforded to spread abroad, and make known in the most distant mining circles, the new automatic jigging process applied to fine grains.

The drawings of the Hartz continuous-jig, there exhibited, are described in the often-quoted excellent work of M. A. Habets (page 625 and Plate X.), with a construction not since improved, except in unimportant details.† The movement of the jig-piston, with a large number of strokes and a small lift, is produced in an effective manner by eccentric cams, hanging in common on a horizontal driving-shaft lying above the piston-boxes, which are placed in a row near each other.

In order to be able to regulate the height of lift, the eccentricity of the cam is made adjustable. In this way, a decreasing height of lift can be given to the jig-pistons from the first to the last sieve of the jigging-machine. In order to make the uplifting of the material more forcible than its fall, the introduction of the water necessary is made in a suitable manner through pipes, which empty into the space under the jig-piston and jig-sieves.

The use of jig-boxes of sheet-iron and cast-iron, introduced by Bérard into France, Belgium, and Great Britain, and spread throughout Germany by the

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* Even where it does not pay to save these finest ore-particles, such a passing of the tailings over plane-tables is recommended, in order to have a check upon the jigging process.

† The jigs constructed there are shown in Kutscher's article on *Die neue Aufbereitungsanstalt zu Clausthal*, in the *Zeitschrift für das Berg-, Hütten-, und Salinenwesen, &c.*, 1873, vol. xxi., p. 85; also described by Riehn in *Engineering*, 1876, vol. xxi., pp. 35, 64, 102, 167, 210, 249 303, 356.

Humboldt Company (formerly Sievers & Co.), has since been found less suitable for the continuous-working jig.

The employment of the long, wooden jig-box, divided into separate compartments by partitions and held together by bolts, has been returned to in preference to the iron one, which rusts away rapidly. In Germany the under portion of the jig-box is often made barrel-shaped, and is kept tight by iron bands laid around it, which are prolonged upward in vertical bolts, provided with nuts and fastened to the sills of the cast-iron, upright standards of the transmission shaft.

The Kasalovsky jig in use on trial at the Blei-Scharley Mine, at Bethen, in Upper Silesia, for the dressing of blende containing galena works very well, since, in addition to the saving of space and power, the piston (lying deep in water) affords the advantage of always working well; while, on the contrary, the common piston, placed higher and working vertically, if not well-packed, is apt to produce a suction of the water, which is detrimental to the jigging process. On the other hand, the apparatus, complicated by stuffing-boxes, needs more frequent repairs, and the transmission applied at the side, is much in the way in tending the apparatus. In the United States, F. Cazin has modified the previously-described arrangement of the jig in such a way that a single, long, rectangular, oscillating piston, lying horizontally, is used for the compartments of the jig, placed behind one another, instead of a special piston for every division. This has its swinging axis near the outlet of the jig, and is moved near the inlet by means of Fairbairn's crank-slide connected with a perpendicular piston-rod. By this means a higher lift is given to the water under the sieves at the inlet than at the outlet, and the jigging-stuff, in the mass, receives lighter shocks as it moves from end to end, and the specific gravity of the ore to be carried through the ore-bed into the under-tub diminishes.

According to Cazin's statement, 140 strokes of 25 millimetres are said to have been given to stuff of 2 millimetres diameter of grain.*

Coarse Grain Bed-Jigging.

The use of the bed-jig has been gradually extended from the fine to the coarse-grained stuff in ore-dressing, so that it may be assumed that this practice of a continuous process has been generally introduced into well-managed ore-dressing establishments at the present day. The special difficulties that show themselves with coarse grains, and which exist partly in the uniformity of feeding, partly in making a proper bed, and partly from the union of various ores in the jig-grains of medium specific gravity, have all been overcome by suitable means.

Omitting the numerous feeding arrangements, it should be observed in regard to the formation of the jig-bed, that hard, angular bodies are better adapted for this purpose than rounded and soft ones, which rapidly wear away. Therefore, in jigging galena, old pieces of iron, with the sharpest edges possible, nuts, bolt-heads, &c., can be used advantageously; in coal-jigging, feldspar, which has about the same weight as the accompanying clay-slate, will do.

For ores disseminated in the gangue only a few (about three) sieve divisions are used in coarse-grained jigs, from the first of which, for example, pure galena is obtained; from the second, richer disseminated ore,—crushed or broken stuff,—which is carried to coarse rolling-mills for further reduction; from the third, poorer disseminated ore,—stamp-stuff,—which goes to fine rolling-mills or stamps to be ground smaller, while the tailings of the third division consist of deads.

In the newest establishments in Upper Silesia, where blende containing lead is dressed, the coarse-grained fine stuff—smalls—are thoroughly worked in continuously-acting jigs, with two divisions only, in order, in the first place, to remove the greater portion of the deads therefrom, and then to treat further by themselves the enriched siftings in two mixed sorts of ore, a richer and a poorer one.

* *Berg- und Hüttenmannische Zeitung*, 1872, p. 189, Pl. V.; R. W. Raymond, *Statistics of Mines and Mining*, Fifth Annual Report, 1873, p. 444.

It may be here mentioned as an example of the simplification and completeness of ore-dressing from the introduction of continuous-jigging, that in the important zinc ore-washing establishment at Scharley, in Upper Silesia, for dressing sands and slimes, 34 round buddles have been supplanted by 6 fine-grain jigs, and 32 old plain jigs by 10 new jigs of 4 divisions each; and that with reference to diminishing the loss of lead the result was attained of reducing the former 1·5 per cent. of lead in the produced zinc-slime to from 0·1 to 0·2 per cent.

Coal-slime Jigs.

The Hartz fine-jigs have also come considerably into use of late in coal-dressing, for cleansing the extremely fine coal-dust, and have become a valuable aid in overcoming difficulties, formerly insurmountable, which opposed the efforts to obtain from impure slack-coal a fuel as free as possible from ash, and adapted to metallurgical and other technical purposes, at small cost.* The drainage air-jig of the civil engineers Riehn, Meinecke, and Wolf, at Görlitz, in Upper Silesia (already mentioned in the 5th section, under 4), forms a worthy completion to the successful carrying out of the endeavours to utilize, in industry, the impure granular coal, previously almost worthless.

Evrard's Coal-dressing Process.

In the historical consideration of the technical advance, it appears especially attractive for the attentive observer to see how often the very hardest problems are solved, in an equally happy manner, by human invention, but by entirely different and widely-varying methods; and how nations, striving for the development of culture, emulate each other. If the old traditions of Cornish, Hungarian, and German mining were the pioneers in the above-considered advances, it must be acknowledged that in France the engineer Max Evrard (of great merit in other directions also) has found out how to overcome the difficulties of an automatic process for coal-dressing by entirely new inventions, of such a kind that his methods of coal-dressing, carried out technically in two entirely different paths, can be placed as of equal value by the side of those above-represented practices, which have already obtained a wider circulation. In one method, next to be considered, the use of a ring-shaped jig-sieve, turning slowly in a horizontal direction, and working continuously, entitles him to the priority, in point of time, of having first solved the problem satisfactorily.

M. Evrard has himself, in several articles, described and represented his dressing establishment and system, and his papers are well known through various German publications.† The beautiful models displayed by him at the Paris Exposition, in 1867, have been deposited in the collection of the *Conservatoire des Arts et Métiers* in Paris.

Under the obliging guidance of the inventor, the author had an opportunity, as long ago as 1864, to admire the original system in its completed form and doing its best work at the Charlotte Mine, near St. Etienne. It was then limited in its operations; the nut coal of less than 12 millimetres diameter, obtained from sorting upon a horizontal, rotating, ring-shaped screen, was mixed with the granular coal of less than 5 millimetres in size (after the finest dust of about 1·5 millimetre diameter had been sifted out of the latter by means of a drum-sieve), and the mixture was then carried to a large ring-shaped, horizontal, rotating jig that was continuous in its working, and there it was washed. The finest coal-dust, which impeded the jigging, was to a small extent sold unwashed, principally, however, thrown upon the dump as worthless. The coal, after being cleared by washing from the dirt acquired in

* T. Nonne, *Notes on the Dressing of Coal, particularly the Coal Dust Washers built in Saxony, Lower Silesia, and Moravia, by C. Lührig*, the periodical *Glückauf*, 1876, vol. xiii., Nos. 5 and 13; 1877, vol. xiv., No. 17.

† M. Evrard, *Bulletin de la Société de l'Industrie minérale*, tome ix., p. 305, 2e sèr., 1873; tome ii., p. 281; *Note sur la lavage des Charbons*, 1875, St. Etienne, Théolier & Co., 1876; Gätzschmann, *Aufbereitung*, vol. ii., p. 121.

extraction, was delivered from the jig in two sorts; the cleaner of which—the first skimmings—contained only 3 to 4 per cent. of ash; the second—the second skimmings—about 6 per cent. of ash; out of the two sorts briquettes were made of first and second quality, adapted for use on ordinary railroad express-trains. A third sort, which was obtained in smaller quantity, as third skimmings, from above the refuse, was used for heating the boilers at the mine.

An entirely similar dressing establishment, at that time building for a mine at Epinac, with engines, boilers, foundation, and water reservoirs, was contracted for by one man at the price of 101,000 francs.

The establishment at St. Etienne requires, in a ten-hour shift, for working up 600 tons, 5 workmen at the jigs, engines, and boilers, and 12 to 15 picking-girls for sorting the slate from the lump and cube coal, with an outlay of 10 centimes (2 cents) per ton for running expenses and maintenance.

M. Evrard had also, even at that time, formed the plan of dressing the finest coal-dust (*moures*) upon a peculiar washing-apparatus, similar in general arrangement to the above-mentioned jig. Its introduction soon after, at the Chazotte Mine, at a cost of 100,000 francs for the new plant complete, produced very favourable results, inasmuch as by it a supply of 40,000 tons of hitherto worthless coal-slime could be worked up and made valuable, outside of the ordinary waste of coal-dust.

Not yet satisfied with these favourable results, M. Evrard, probably a few years after the Paris Exposition of 1867, produced an entirely new and peculiar washing-apparatus for cleansing in bulk the raw material from the mine after the lump and cube coal have been screened out of it, without any previous sorting into nut, pea, and dust sizes, by uniting the principle of free-fall in a high column of water at rest, and that of the intermittent effect of jigging, with his own ingenious invention.

This hydraulic classificator (*laveur classificateur*), which first came into use in 1873, at the Coke and Tar Distillery of Carrès & Co. at St. Etienne, serves at the same time for cleaning and drying the coal-dust or slime, as well as for separating and first-washing the nut and pea coals. The latter must still be carried from this apparatus to a jig worked on the usual principle in order to obtain a clean product. The Evrard ring-jig is at least as well adapted to the purpose as any other continuously-working jig. This latest system has the special advantage over all other methods of coal-dressing of rendering completely unnecessary the previous sizing of the small coal on special screens and drums, and also in simplifying very essentially the machinery to be maintained.

Since reference has been made to Evrard's essay, published in the *Bulletin de la Société de l'Industrie minérale*, 1873, with excellent illustrations of all the details, it will suffice in this place to set forth briefly the essential characteristics of the various apparatus before mentioned.*

Evrard's new ring-sieve jig consists of a funnel-shaped reservoir of masonry laid in cement, with an inside diameter of 10·20 metres and a depth of 10 metres, whose apex ends in a pipe provided with a stop-cock, by means of which the slimes collected in the reservoir may from time to time be drawn off into cars.

Within the reservoir is built a circular partition-wall, which divides it into an annular compartment for the ring jig-sieve and a central cylindrical compartment for the piston, which consists of a floating sheet-iron cylinder with closed bottom, and the partition is provided with a number of openings at the bottom to unite the two compartments.

The cylindrical piston has a diameter of 5·30 metres, and is raised by means of a single-lift cam, on a horizontal shaft, working against the under surface of the piston.† The down-stroke is regulated by means of weights placed on top.

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* For this purpose use has been made of correspondence, for which the author is especially indebted to the kindness of M. Evrard, and also of more complete data concerning the latest results and uses of his dressing processes in France.

† In the old construction, in use at the Chazotte Mine, the piston was raised from above by means of a long single-arm counterweight of sheet-iron.

The jig-sieve consists of an annular surface 2 metres wide, with an outside diameter of 10 metres, which is inclosed within two metal-plate rims 30 centimetres high; and is provided with a grate-bottom of wooden slats arranged radially in part, and partly in circles, upon which rests a copper-plate bottom forming a sieve, with holes of 1 millimetre in diameter. The lower edges of this solidly-joined ring-sieve turn upon radial and horizontal friction-wheels set upon the masonry, and a slow circular motion is given to it by means of a toothed wheel fixed to its outer circumference, into which works a small driving spur-wheel with a vertical spindle.

The surface of the ring-sieve is inclined about 30 centimetres in its greatest diameter, and the water is kept at such a height that the sieve-bottom in its lowest position is 20 centimetres under water, but at its highest point is 10 centimetres above the surface. In this manner the uniform radial and continuous stroke of the cylindrical water-piston works with varying force upon the immersed portions of the jig-sieve; and, consequently, on account of the rotatory motion of the latter upon each particle, from the beginning of the immersion down to the lowest point, with gradually increasing force, and from there up to the withdrawal of the sieve with a similarly decreasing intensity of the hydraulic stroke.

The jigging-stuff was originally charged upon the sieve in a dry condition by means of an elevator. By that means, however, on immersion, the finest particles of coal and the deads, on account of the oscillatory motion of the water, go together through the sieve into the slime-funnel beneath. After a separate working of the coal-slimes with grains of less diameter than 1 millimetre had been effected by means of special apparatus, M. Evrard modified the manner of charging the stuff by sorting the coal-slimes that interfered with the jigging process, and at the same time dressing them by themselves.

The dry, screened, granular coal to be washed is carried in a powerful stream of water through two systems of drum-sieves situated above the jig. The first system of two drums sifts out the grains of 2 millimetres diameter and greater, and carries them directly upon the part of the jig covered in its immersion. The second system, having only one drum with holes 1 millimetre in diameter, in turn sifts the finer grains of 1 to 2 millimetres diameter from the tailings of the first system, and carries these grains to the part of the jig most deeply immersed, where the previously charged coarse stuff has already been separated into layers according to the size of the grains, and now serves as a suitable jig-bed for the finer grains falling upon it, so that only the refuse is allowed to pass through.

In a measure, as the jigging-stuff on the ring-sieve rises more and more out of the water, the hydraulic strokes become weaker, until the water recedes from the coal entirely, and, under the influence of the oscillating air pressing in from below, drops off. Since the lower layers of coal-grains serve as a filter, the upper layer of fine slime is also drained just as completely as the lower ones.

On the upper part of the ring-sieve are stationary scrapers which carry off the uppermost layer of washed coal to an elevator-wheel used for removing the stuff. There are three such forwarding apparatus, one behind the other, for continuously discharging the washed coals Nos. 1 and 2, as well as the impure refuse, and also, according to circumstances, the coal rich in ash or the entirely barren deads into cars placed underneath.

The fine slime from the drum-sieve is conducted to a peculiar funnel-shaped settling-apparatus—décanteur—of 2·4 metres width at top and 4 metres depth, in which the finest grains sink to the bottom and, in company with about one-fourth of the tailings, are conducted through a pipe leading up from the bottom to the slime-jig, while the three-fourths of the tailings, which go over the edge sufficiently clarified, flow with the superfluous waste water of the washing apparatus to a pump, which raises them again; so that after another clarification in a pointed-box, 6·6 metres long and 2·4 metres wide, they are used over for feeding the sorting-drums.

The slime-jig is similar in construction to the previously-described jig for sorting granular stuff.

The ring-sieve is, however, only 1 metre wide, and has an outside diameter of only 6 metres, and consists of two concentric annular compartments, the

inner one having a tight bottom of sheet-metal, the outer one a perforated bottom, the two being separated by a metallic rim. In the inner compartment the slimes deposit themselves in layers and, after sufficient draining, are turned over in the outer compartment by means of an elevator-wheel, in order to be washed clean by the jigging process during the following revolution of the ring-sieve. The jig-piston, which is only 1·2 metres in diameter, is placed not in the middle, but on the side of the ring-sieve, and is separated from the jig-box by means of pressure-valves, on the principle of the jig-pump, and provided with especial suction-valves; so that only an intermittent rising stream of water works upon the ring-sieve. The combination of the two jigs for the separate preparation of the granular and slimy stuffs is generally satisfactory, although the rather complicated mechanism and, more especially, the fact that in the preparation of the slimes there is an unavoidable loss in the clayey, sandy tailings which contain many coal-particles, induced M. Evrard to try an entirely new way of systematically and thoroughly removing the difficulties arising from the coal-slimes.

His above-mentioned hydraulic classificator, described in 1873 in the *Bulletin de la Société de l'Industrie minérale*, consists of a vertical, hollow prism, either cylindrical or rectangular, 3 metres deep, whose bottom is formed by a movable piston-like inclosing rim, covered with a perforated plate, which can be raised to any height desired, as far up as the rim of the vessel, by means of a piston-rod attached to the under side and an upright hydraulic cylinder working upon it.

The vessel is prolonged beneath the piston in an open pipe of the same width and about 4 metres long, and both are submerged in a wider water-cistern, closed above and below and steam-tight, whose cover is closely riveted to the outer covering of the vessel, and is provided with a steam supply-pipe. By means of an intermittent supply of steam from the boiler, through the cover, into the upper part of the outer holder, the water therein receives an oscillating, jerking motion, and works upon the minerals which are fed into the vessel and become heaped about 1·33 metres high upon the piston-sieve, just as with a jig-sieve. The only difference is that the hydraulic strokes are much stronger at the start, being given with a lift as high as 20 centimetres, and then decrease to a few milimetres; so that the action which follows at first, just as with a slime separator, changes gradually to the action of a fine-jigging machine.

In this way a pause of one or two minutes is given, in order that the finest slime may properly settle on the piston-sieve, and then this piston is raised intermittently to the upper edge of the inner vessel, in order to scrape off the jigging-stuff over the edge in different layers, according as they lie upon the piston after sorting, and to obtain them separately as special products. The whole operation lasts about five minutes.

For drawing off the sorted coals in layers, a moveable metallic scraper in the form of a ring is attached to the upper edge of the washing vessel, and motion is imparted to it by means of a horizontal hydraulic cylinder when removing the coal, and when empty it is carried back by means of a counter-weight and chain.

Without going further into the ingenious particulars of the apparatus for effecting the direct employment of steam, partly for imparting an oscillating motion to the water-column of the jig-sieve, partly for the production of the requisite pressure of water for working the hydraulic piston, and partly for feeding the stuff into the jig, it will suffice to mention briefly, in this connexion, the practical results of this new method of dressing.

The washed products deposit themselves upon the piston jig-sieve in such a manner that the uppermost layers are made up of the cleanest possible coal-slimes, under which is found the granular coal, whose coarseness increases with the depth; below this again is the lump coal, which is more and more impure as it lies lower on the jig, while, finally, in the lowest layer of all, merely slate is found.

The tailings that pass through the sieve of 3 millimetres mesh into the lower receptacle consist only of fine particles of gangue without a trace of coal in them. On removal, the cleaned products are found in a compact cake on the sieve. If the upper sufficiently-purified part of this cake, which at

top consists of slime coal and at bottom nut coal, be drawn off all at once by the scraper, the mass crumbles to pieces in the trough leading to the cars placed below to receive it, and a mixing of the finer and coarser layers takes place so completely that the scrapings may be fed directly into the coke-ovens.*

Besides the fine sand, rich in ash, contained in the middle layer of coarser coal, there are smaller lumps of coal with slate attached, distributed through the entire height according to their size. If this impure portion be removed by layers in separate lots, and if these lots are sifted upon special sieves of suitable mesh, then the finer and specifically heavier particles mixed therein may be separated by this means from the coarser grains of coal. Yet such a proceeding is not to be recommended in coal-washing; it is better and easier to obtain coal sufficiently free of ash from this middle layer by means of a preparation upon the above-described ring-sieve jig. For this purpose M. Evrard carries the middle layer of the classificator directly to the neighbouring ring-jig, which he arranges in such a manner that the clean-washed coal thrown upon it falls into a hopper, to which place the top layer of pure slime and the fine-grained coal from the classificator come; so that the desired mixture of both kinds takes place of itself.

In order to drain the washed coal, there is placed beneath the hopper a concave sieve, which revolves slowly, and the coal, after being stirred up by rakes, and pushed from the middle to the circumference of the sieve, drops into the car of the coking-works sufficiently dried.

The first combined establishment of this kind was erected in 1875, by the Firminy Company, at the Roche la Molière Mines, near St. Etienne. The classificator there has a rectangular piston-sieve, with a surface of 6 square metres. The works were built by Messrs. Revollier, Bietrix, & Co.

The after-jig of this establishment is of a peculiar construction, and has not yet been described. It will be made public for the first time at the forthcoming Exposition at Paris, in order not to hinder the obtaining of a patent-right in other countries.

The two cleansing apparatus so combined require but one attendant. The classificator works up 20 to 30 tons of material in an hour, while the cost of washing is reduced to a minimum. M. Evrard names 100,000 francs as the original outlay for a classificator with a capacity of 200 tons in 10 hours.

The first classificator washing-apparatus, erected in 1873 at the coking establishment of Corvès & Co., already mentioned, worked without the ring-jig, and had only one piston-sieve, with a surface of 1 square metre. It yielded 1,000 kilogrammes at each operation, working only 75 operations in 10 hours, whereby one apparatus superseded twenty of the piston-jigs formerly used. With quicker working the apparatus could wash over 100 tons (100,000 kilos.) in 10 hours.

Besides its use at the above-named works, the Evrard classificator is in operation at the smelting-works of Petin & Gaudet, at Givors, on the Rhone, and at the mines of Montal-Sorbin, near St. Etienne; and is in course of construction at the mines of Epinat, in the department of Saône and Loire, as well as at Barruele (Compagnie des Chemins de fer du Nord de l'Espagne), in the province of Valencia.

Pneumatic Jigs.

The principles of the method of pneumatic dressing, by Stephen R. Krom, of New York, have been thoroughly explained in the theoretical section.†

The apparatus consists of a firm cast-iron frame, forming a rectangular box, open at the bottom, which, in the upper portion, contains a fan, pro-

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* In washing coals containing lignite rich in ash, the latter forms foamy masses floating upon the toughest slimes, and makes the cleansed coal-slimes impure. In Evrard's classificator this ashy foam occurs in the very uppermost layer of the washed cake, and may be skimmed off of it with a shovel before removing the mass.

† "It should here be observed that pneumatic jigging, upon several layers of sail-cloth resting on wire sieves, placed in steps one above another, had been proposed fifteen years previously by Aufermann, and, as it appears, had been used for dressing amalgam residues." —Gätzschmann, *Aufbereitung*, ii., p. 124, from *Berg- und Hüttenmännische Zeitung*, 1862, p. 427.

vided with leather valves and lying flat, which swings upon an axis, and compresses the air; it also has, on the front side, a grate-like sieve-bottom and a wedged-shaped receiver, and in a niche in the end of the cast-iron frame, closed tight by a door, to protect it from dust, is the mechanism for moving the fan and for regulating the jigging. The case is 1·523 metres (5 feet) long, 0·914 metres (3 feet) broad, and 0·940 metres (3 feet 10 inches) high. A cast-iron hopper is screwed on top of the case, through which the crushed stuff is conducted to the ore-bed. Two sluice-boards, edged with plate-iron and set by thumb-screws, serve for regulating the feeding of the stuff and for discharging the specifically lightest grains (tailings). The stuff is fed close to the bottom of the sieve, which is 127 to 133 millimetres (5 to 6 inches) broad. The tailings fall over the upper edge of the second sluice-board. The sieve-bottom consists of numerous ⊓ shaped hollow bars, which, like grate-bars, lie crosswise at regular distances from each other, and with their hollow sides opening into the compressed air-chamber over the fan. The intervals, or grate-spaces, between the hollow bars, are closed tight by separate wooden blocks, so that the compressed air enters the ore-bed only through the hollow bars. The width of these spaces is $\frac{3}{16}$, $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inches, varying with the size of grain of the material to be dressed. While the charge is gradually moved along over the grate-bars and spaces by the impact of the compressed air, the specifically heavier grains fall into the spaces, and through these continuously into the receiver underneath. This is always kept full by means of a ribbed roller whose more or less rapid revolutions accurately regulate the proper rate of the jigging. The height of the space is so adjusted that the compressed air from the hollow bars can only escape upwards. The fan is provided with lattice-like openings, covered by leather valves, and reinforced at the axle with a leather strap. The swinging end of the fan moves as closely as possible to a longitudinal iron bar, whose surface of contact is a smoothly-planed concave section of a cylinder. The compression of the air takes place by the swinging of the fan in an upward direction, with very little dead space, uniformly over the whole breadth of the jig. Motion is imparted to the fan by means of the mechanism in the attached side-chamber, with the very great velocity of 7 to 8 revolutions per second, in the following manner: The lever, fastened to the fan-axle, is limited in its movement from right to left at its lower end by means of a leather band, which is adjusted on the outside by a set-screw, and it is drawn in this direction by a horizontal, spiral steel spring. By means of a friction-roller bolted to the middle of the lever the latter rests against the evoluted teeth of the cog-wheel, placed on the driving shaft. On the other end of the driving-shaft are the belt-pulleys, used for throwing the driving-belt of the machine on or off. The fan, therefore, while drawing in air, is moved downward by the cog-wheel with uniform velocity; the upward movement for compressing the air, on the contrary, takes place suddenly, by means of the stretched spring, whose force diminishes with the increased compression of the air. The leather band must be so arranged that the friction-pulley shall never strike the cog-wheel at the base of the tooth. The author had opportunity to observe the machine in operation at the Centennial Exhibition, and notwithstanding the rapid up-and-down movement of the fan the spring mechanism, by means of this ingenious arrangement, worked without perceptible shock or vibration. In the side-chamber, at the end of the fluted roller used for discharging the grains that have passed through the jig, there is a ratchet-wheel, which is revolved slowly by means of a pawl connected with the driving-shaft. The extension of the pawl is regulated at pleasure by means of a set-screw, in a slot on the side of the cog-wheel. The separation is more effective in proportion to the sharpness and intensity of the air-puffs. The execution of the jig, on the other hand, depends upon the number of lifts,—*i.e.*, the greater or less velocity with which the air-puffs follow each other in a given time. The weight of such a machine is given as 1,200 pounds, and its capacity $\frac{1}{2}$ ton per hour, requiring $\frac{1}{5}$ horse-power. The inventor also furnishes very small pneumatic jigs, only 150 pounds in weight, for $250, which are adapted for sampling ores in laboratories.

On comparing the continuously-acting hydraulic jig with Krom's pneumatic one, the very small length (only 5 or 6 inches) of jig-bed of the latter

presents a decided advantage, since, with a comparatively small apparatus, large quantities of ore can be worked up.*

On the other hand, it must be considered that the hydraulic fine-grain machine, with several successive sieves, gives a whole series of different products, separated by one operation, while the pneumatic machine separates only two products at each operation. But by closer observation it is found that the method of producing only two products affords practical advantages, especially with poor material, and is, therefore, used in hydraulic jigging at the copper mines of Lake Superior, because the greatest portion of the jig-stuff in the gangue is extracted at the first operation; so that then only the smaller concentrated portion remains to be subjected to the further more careful manual operations used to avoid loss of ore.

According to late reports, pneumatic jigging has already been extensively and successfully used in the mineral districts of Spain where there is a scarcity of water. At all events, according to present experience, it affords a new aid of great technical importance for such ore districts in the mountainous regions of hot climates, as it permits ores to be made of use which hitherto have remained wholly worthless in the ground, or have been thrown upon the dump as valueless.

Pipe-Apparatus with an Ascending Stream of Water.

Since Von dem Borne's early experiments, the pipe-shaped apparatus, with an ascending stream of water, have undergone a good many modifications and have been used in numerous ways, not only as a substitute for the labyrinth in sizing fine ore-meal, but also in the separation of certain sandy slichs coming from the round-buddle or slime-pit processes, which still form mixed products.

Since the introduction of continuous fine-grain jigging, however, the use of these machines for concentration has been abandoned on account of their great consumption of water.

In dressing the finely-disseminated lead ores occurring in the soft sandstone of Bleiberg, near Commern, in the Eifel, near the Rhine, a pipe-apparatus invented by Osterspey, and called siphon-washer (Heberwäsche), which acts on the principle of an ascending stream of water, has attained a practical local importance for washing off the sand from the fine lead-ore grains (Knollen).† It consists of a wooden vessel divided into two compartments, which communicate with one another and form a continuous pipe, and in one of these compartments, which is provided with a constant flow of water, is a float hung upon a one-armed lever, while the other compartment, from which the water discharges over a broad dam, contains a funnel-shaped, fine-meshed sieve, upon which the sands containing the lead ore to be dressed are fed continuously. In the apex of the sieve-funnel there is a narrow outlet-pipe,

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* The quicker separation of dry ore-grains in a stream of air, as compared with the effect of hydraulic jigging, must be attributed to the lesser influence of adhesion. With fine ore-particles, especially those composed of thin scales, which, in water, adhere to larger grains of gangue, or form by themselves a compact pulpy mass, the process of separation is delayed by adhesion, and prevents the laws of the free-fall of bodies in a fluid medium from acting with mathematical accuracy.

The author had only the experiments of Mr. Krom in relation to the theory of pneumatic jigging when writing the theoretical part of this report. Since then an interesting theoretical comparison of the laws of the free-fall of small spherical bodies in water and in air has been published by Mr. J. C. Bartlett, of Cambridge, Massachusetts, wherein he proves that, in Krom's experiments of fall in narrow tubes, the more favourable effect of an ascending stream of air, as compared with that of an ascending stream of water, upon the suspension of balls of unequal diameters and different specific gravities, is due to the narrow cross-section of the glass tubes used in the experiments, and that in sufficiently wide glass tubes, on the contrary, the separation must prove more favourable in water, by reason of the greater density of the medium, as already stated by the founders of the theory of ore-dressing. (J. C. Bartlett, *The Action of Small Spheres of Solids in Ascending Currents of Fluids, and in Fluids at Rest. Engineering and Mining Journal*, 1877, vol. xxiv., pp. 102, 129). However, it must not be overlooked that, in pneumatic jigging, the equal falling grains suspended in the stream of air are always in narrow air-spaces, and that in this case the larger grains in comparison with the adjacent smaller, but specifically heavier grains, are similarly situated to those in Krom's experiment in narrow glass tubes. In the opinion of the author, therefore, practical experience alone can decide which process, the hydraulic or the pneumatic, can effect the closer separation according to specific gravity and size of grain.

† A. Henry, *Préparation mécanique, &c., Ann. des Mines*, 1871, 6 sér., tome xix., p. 355 Pl. X., Figs. 8, 9, 10; *Engineering and Mining Journal*, 1877, vol. xxiii., p. 121, with plate.

closed by a stopper. As soon as the lead ore, cleared of sand by the ascending stream of water, heaps itself up to a certain height above the sieve-funnel, and the passage of the water is thereby hindered, the float is lifted by the rising water-level, and this in return raises the stopper fastened to the float-lever by means of a perpendicular rod, so that the lead ore is carried off through the outlet-pipe automatically. The apparatus is especially distinguished for its very great working capacity. According to A. Henry, one machine, using ¼ cubic metre of water per minute, works up from 1,500 to 1,600 tons of sand, containing lead ore, per day of 24 hours.

In 1868 Mr. Dor, the engineer of the zinc smelting-works at Ampsin, in Belgium, repeatedly constructed, with favourable results, at the coal mines around Seraing, a slight modification of the slime separator (*Stromapparat*), employed for sorting stamp-meal, for washing the slime, very rich in ash, which was obtained from the coal-jigs at the coal mines.

An apparatus consisting of a sheet-zinc cylinder of 0·29 metre diameter and 0·50 metre height, provided with the necessary feeding and discharging arrangements for coal, water, and refuse, worked up the slime-tailings from four Bérard jigs. This coal-slime contained 45 per cent. of ash. One machine works up from 10 to 12 tons of such slimes in 12 hours, with four workmen for feeding the slimes and for cleaning out the receiver, and requires six cubic metres of water per hour; seven tons of washed coal, containing 15 to 18 per cent. of ash, was obtained by it. The cost per ton amounted to 12·80 francs.*

Settling Apparatus.

Of the settling apparatus, used for concentration, which have been mentioned in the theoretical portion of this report, the small round buddles (Fallkreisel), such as Von Sparre's "Drehpeter," Von Rittinger's "Setzrad," and Hundt's "Stromsetzmaschine," have scarcely more than a historical interest, having been pushed into the background by the Hartz continuously-acting jig. In fact, about 12 years ago the last-named machine could, according to the experiments made at that time at the Landeskrone Mine, in Siegerland, still be called an important step in advance.† Evrard's settling apparatus has already been discussed under jigging-machines.

The English dolly-tub or tossing-keeve (Rührfass) may be mentioned in this place as a very old apparatus, but one which has remained in use until now.

In the simple form of a tub provided with a fly-spindle, which can be easily taken out, it is used to this day for the final washing of slichs difficult of separation. The fall of the ore-grains is thereby effected, partly by the centrifugal force of the rotation, partly through vibrations, to which the rotating ore-slime is subjected by hammering upon the iron bands of the tub.

Slime Tables.

After the thorough discussion of the various forms of the tabular slime apparatus for the concentration of mealy stuff containing ore, in the theoretical section of this report, but little remains to be said about the construction and management of these apparatus. They have, for the most part, disappeared from dressing establishments since the jigging process has been applied more and more to fine sands or meal.

The German slime-pit and the English round-buddle, working in a similar manner, adapted only to coarse sands, are in use, at the present time, in isolated cases alone.

Yet for working up large masses of poor, coarse, but still fine tailings, containing ore-particles (Aftern), the convex conical-buddle, where labour is

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* *Berg- und Hüttenmännische Zeitung*, 1872, p. 400, from A. Habets, *Revue Universelle des Mines*.

† R. Jordan, *Zeitschrift für das Berg-, Hütten-, und Salinenwesen*, 1866, xiv. 197.

cheap, still does good work, because the fine meal is deposited on the apex of the cone, while the coarse barren sand rolls to the foot of the cone; just as in the German slime-pit the inclination of the table, during the descent of the layers of meal fed upon the conical table surface, is kept uniform through the gradual heaping up of the tailings which collect at the edge of the table.

Hundt's funnel-table or concave-buddle, used at Siegen, is recommended for similar stuff; but it appears less adapted to the separation of small quantities of ore from large bodies of barren sands, because the conical surface itself presents for the former at the apex and for the latter at the circumference, the correspondingly smaller though relatively larger space.

Both kinds of tables give middle products only, which require a further concentration by other apparatus and intricate succeeding processes. Irregularities and great loss of ore are unavoidable on account of their requiring the constant attention of the workmen. The old-fashioned plane and sweeping tables have been retained to a limited extent for certain after-processes, and for dressing tough slimes, by the side of the rotating concave and convex-buddles. The plane-tables are especially serviceable for retaining the finest floating particles or ore from out the dead, rough sands, and are often used for this purpose in ore jig-washing, and especially in gold quartz stamping.*

A. Henry states (in the work already quoted, p. 359) that a rotating convex-buddle of 3 metres diameter, at Silberau, near Ems, on the Lahn, works up about 1 ton of slime in 10 hours. By a combination of two cast-iron convex-buddles, one over the other, the upper one 2 metres in diameter, the lower 3 metres in diameter, the quantity washed there in the same length of time was increased to 5 tons.

At the Central Dressing Establishment at Clausthal, in the Hartz, in a similar combination, the upper buddle was 5·3 metres and the lower one 4·5 metres in diameter. Concave and convex-buddles were also often so arranged on the same spindle that the concave-buddle was on top.

In the very large rotating convex-buddles used at the washing-works of the copper mines of Lake Superior, according to M. Rolker, who (in the work above quoted, p. 296) has given clear drawings of the construction, the diameter is 5·486 metres (18 feet), the inclination of the table 5° 39′; the number of revolutions from $1\frac{1}{4}$ to $1\frac{1}{2}$ per minute. A special conical surface—Evan's patent apron—is used there for feeding. The concave and convex-buddles, besides their comparatively small working capacity, are objectionable, because the slichs obtained from them still require, as a rule, complicated later processes in order to give sufficiently pure products for smelting purposes. For instance, the sharp separation of blende from lead ore, essential for metallurgical processes, cannot be effected satisfactorily.

The old percussion tables, formerly in general use in Germany and Austrian Hungary, are adapted neither to coarse sand nor to very tough slimes, and require extremely complicated subsequent processes for the middle products. They appear best adapted for cleaning slichs previously concentrated on other apparatus. In German dressing establishments the end-blow percussion-table has been supplanted by the previously mentioned round-table. At British ore mines it seems to have never been introduced.

The continuous end-blow percussion-tables, with delivery above at the head end and below at the tail end, tried by Mende, director of machinery in Freiberg, in 1797, and later again brought into notice by Hardt and Stapff, have never become of any practical value. Nevertheless, as has already been mentioned in the theoretical section, a similar apparatus, though in isolated cases, has been recently used successfully, it is said, in copper washing at Lake Superior.†

Theoretically, much can be said in their favour, because their length can be reduced to a minimum, and, in addition to the percussion, still other effective mechanical forces can be made use of, depending on the way the vibration is applied, in order to produce a close separation according to specific gravity.

* Heberle has, in the dressing establishment at Fahlun, made use of the small continuous table, provided with an endless cloth, to extract the gold slich from the copper pyrites slich concentrated on the side-stroke percussion-table.

† August Heimbach, dressing engineer at Franklin, near Houghton, Michigan, who has patented a similar apparatus, is pursuing this subject with especial zeal.

The steadily working cross or side-blow percussion-table has attained great importance. It is one of Rittinger's lucky inventions, and depends upon the principle that mineral grains washed downward on a slightly inclined table surface are driven by side-blows into diagonal curves, diverging in proportion to the specific gravity of the grains, and the different sorts of minerals separated in this way are distributed into receivers lying at the lower end of the table.

The original plan of the inventor was first tried, with doubtful success, about 20 years ago.* Palmer, in Olahlaposbanya, in Hungary, first succeeded, through a change of construction, in obtaining a moderately successful result. The formation of a smooth, durable table surface, and of an immovable foundation, as well as the corresponding adaptation of the percussion mechanism, appear for a long time to have presented difficulties at the Austrian dressing establishments which prevented a rapid adoption of the apparatus.

According to Rittinger (*Aufbereitung*, p. 459), four tables, eight feet long and four feet broad, worked up together 10 to 12 tons of stamp-meal in 24 hours, with a driving force of one horse-power, and with from 70 to 140 strokes per minute.

While in the German dressing establishments the side-blow table found little employment beside the rotating convex and concave-buddles, which were preferred for the working up of tough slimes, it reached a very high degree of perfection in Belgium, and, indeed, as it appears, first at the Bleiberg-ès-Montzen Mine, and at the Altenberg (Vieille Montagne) Company's mine at Wilkenradt, and from that time forward, for the past 10 years, has extended rapidly to other countries.†

According to M. Henry's communications these favourable results depend on the following improvements. The number of blows was considerably increased, to 200, 250, and even 300 per minute, in which case the adjustable play was about 10 to 12 millimetres. Instead of wood the cam-shaft was made of iron, provided with one or two cams, and the complicated and unreliable system of levers, used for transmitting the pressure of the cam to the table, was either replaced by a simple iron force-bar led by a connecting rod or set aside entirely. The foundation frame, of wooden beams, is made very large, with solid foundation walls, and is firmly secured to the spring-beam, against which the table strikes by the action of the springs that are composed of strong wooden beams fastened together, and are stretched by the cams. The percussion-table frame was constructed of angle-irons, united at the corners by plate angle-pieces, firmly riveted from below, and the wooden springs were exchanged for evolute steel springs. The cost of such a double table, with Rittinger's beautiful working plans, and including the feed-roller (Drehgumpe) is stated at 1,573 marks, but it may now, by the use of Bessemer steel, be made considerably cheaper.‡

In Austrian Hungary the greatest variety of materials has been used for producing a durable, smooth table surface; for example, maple, zinc, linen, and india-rubber, with which the table bottom, composed of planks joined together and supported by a strong wooden frame, was covered.

In Belgium they adopted tables of sheet and cast-iron, and in fastening them the expansion through heat was considered, in order to avoid warping. Even with these, especially in the cast-iron tables, the formation of rust was troublesome. Plate-glass cracked easily. Finally smooth stone slabs of marble or slate, which were made the size of the table and two to three centimetres thick, proved the best.

In order to prevent the often observed, slow, sidewise creeping of the wooden sills upon their foundation, it is said that in the dressing establishment at Dam, on the Schelde, near Antwerp, for working up Sardinian blendes containing very finely disseminated lead ores, each pair of percussion-tables had a cam-shaft in common, so that the spring-beams of both

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* Hingenau, in the Austrian *Bergwerks-Zeitung*, 1858, p. 271; Rittinger, *Erfahrungen*, 1862, p. 83; Gätzschmann, *Aufbereitung*, vol. ii., p. 493.

† A. Henry, *Préparation mécanique*, *Ann. des Mines*, 1871, 6e sér., tome xix., p. 364, Plate XI. The theoretical effect of the side-blow table is here thoroughly developed.

‡ P. von Rittinger, Second Supplement to the *Lehrbuch der Aufbereitungskunde*, 1873, p. 57; Atlas, Fig. 328.

percussion-tables were held together by the same main sill, and the effect of the impulsion from one side neutralised that from the other.

In order to obtain a sufficiently durable table surface and to simplify the mechanism, the double tables, already invented by Rittinger, were usually employed, in which the table frame formed nearly a square, with sides about two metres long, and each single table surface was 0·9 metre broad.

The table surface, at the lower end of the table, is in Belgium divided into four compartments by three tongues, which guide the separated ores, lead ore, blende containing lead, blende refuse, and deads, to the receivers arranged for them.

The slimes reach the table on the part of the head that is opposite to the cam, while on the other part of the head (the side on which the blow is given) clear water is introduced for cleansing. The specifically heaviest, but small, ore-grains go, with the greatest inclination, diagonally across the table towards the percussion side, and are hereby driven downward and cleansed by the very strong current of water.

The deads follow a direction corresponding to the inclination of the table, and therefore continue down to the foot upon the same side on which they enter. Upon the introduction of the side percussion-table at the Bleiberg washing establishment (see above) a difficulty arose from the fact that the deads still contained about 2 per cent. of lead, while the specifically heavier blende refuse, delivered alongside of them, was wholly free from lead. It was found that this lead occurred in the form of extremely thin scales, which floated on the top and were carried away by the current of water without touching the surface of the table. By laying a straight, thin cleat on the surface of the table, in a diagonal direction from the middle tongue, between the second and third delivery divisions, to the foot of the table and towards the feeding side, this trouble was fortunately removed. By this means the lead ore scales in question had an opportunity to sink upon the surface of the table in the water held back by the cleat, and then by means of the shock to reach the percussion side. In case one such cleat is not sufficient a second is fastened somewhat lower down on the table.

In its working capacity, and in the small cost of labour, the side percussion-table is about equal to the rotating-buddle. According to Henry a Belgian side percussion-table, with two compartments, works up from three to seven cubic metres of meal in 10 working hours, using one workman for bringing and carrying off the stuff.

Its essential advantage over the rotating-buddle is the superior purity of the product, and the avoidance of further concentration of the slich, which is generally necessary on other tables.

The lead slich is obtained with from 75 to 80 per cent. of lead and from 1 to 2 per cent. of zinc. The side percussion-tables have been especially useful for dressing the very finely disseminated ores, which, as at Dam, near Antwerp, contain a very close mixture of galena, blende, iron pyrites, and copper pyrites.

Magnetic and Electro-Magnetic Concentration Apparatus.

In the separation of a mixture of iron ores and of ores containing copper or zinc,—copper pyrites or blende,—in which the specific gravity of the separate component parts varies little or not at all, it is impossible to use a concentration apparatus which works entirely through the difference of specific gravity. But, if the iron ore is magnetic, like the magnetic iron-stone, consisting of magnetic oxide of iron, or if they can be changed into this black oxide by roasting, like spathic iron ore, then the grains of iron ore can be extracted from the mixture by magnets or electro-magnets, and the more valuable portions—that is, the copper or zinc ores—may be concentrated to the degree required for metallurgical purposes.

With copper ores, this treatment has lost much of its practical importance, through the advance made in the extraction of copper from poor ores by the wet way; but for zinc ores, on the contrary, it still deserves especial consideration.

The electro-magnetic treatment has hitherto been preferred to the use of the steel magnet, because the separate electro-magnets of the apparatus could be so arranged that they attracted the grains of iron ore and then let them go again upon the breaking of the electric current; while, on the other hand, steel magnets must be provided with brushing arrangements to sweep off the attracted iron-ore particles from the magnets. The electro-magnetic machines, however, require special additional apparatus, costly to make and maintain, for producing the galvano-electric current.

At the important magnetic iron mines at Traversella, in Upper Italy, the problem is how to free the magnetic iron ore from the finely-disseminated copper pyrites, containing about 2 to 4 per cent. of copper, in order to produce pig-iron free from sulphur and copper, and further of obtaining about as much more copper ore from an intimate mixture of magnetic iron and iron and copper pyrites which had hitherto never been extracted from the mine. This was fortunately solved in 1858 by Mr. Sella, whose services in Italian mining, and in the gigantic work of first piercing the Alps at Mont Cenis with a railroad tunnel, are widely known.

According to the published papers of Dr. Bernoulli, and the excellent drawings accompanying them,* Sella's electro-magnetic apparatus consists of a cylinder, composed of 54 radial electro-magnets, making about 10 revolutions per minute around a horizontal shaft; under this cylinder an endless belt, about 37 centimetres broad, moves slowly over pulleys, in order to carry the finely-reduced and well-dried ore-meal from the hopper and deposit it under the cylinder in the direction of its length. The electric current, produced by 6 large Bunsen cells, works on the electro-magnets in such a way, by means of the arrangement for opening and closing the current in the copper coils, that they become magnetic directly over the feed-belt, in order to draw out the fine particles of magnetic iron from the layer of meal passing along on the belt, and to hold them during one-eighth of a revolution of the belt from its lowest position.

At this point the current is broken in each electro-magnet in succession, and the magnetic attraction is withdrawn, so that the attracted particles of iron fall upon two inclined slides placed at the sides of the feed-belt, the upper of which catches the pure magnetic iron ore, but the lower one the particles, containing copper, that are carried along in less quantity and require still further concentration. The feed-belt carries the copper ore-meal, freed from magnetic iron, to a receiver.

The electro-magnets, in three rings (of 18 elements each), placed behind one another on the shaft, are so uniformly divided that during the slow movement of the feed-belt every point covered with meal shall be scraped over by the magnetic poles.

The machine is made in Paris, and costs 5,000 francs at Traversella.

At the time of Dr. Bernoulli's visit there were two machines in operation, each of which worked up 150 kilogrammes of ore-meal per hour, and obtained from it about 87 kilogrammes of purified magnetic iron ore and 44 kilogrammes of copper ore containing 8 per cent. of copper.

The cost of dressing 1,000 kilogrammes (1 ton) of the ore was—

Previous sorting of the ore	1·60	marks.
Transport to the crushers	0·12	„
Grinding	1·10	„
Labour at the machine and oversight	1·36	„
Maintenance of the battery	2·19	„
Lighting	0·21	„
Repairs	0·02	„
Interest and sinking fund	0·20	„
Total cost of dressing	6·80	„

From this is to be deducted the value of the magnetic ore obtained (587 kilogrammes), 3·20 marks, and there remains for the cost of dressing 300 kilogrammes, containing 8 per cent. of copper ore, 3·60 marks.

* *Zeitschrift für das Berg-, Hütten-, und Salinenwesen*, 1861, vol. ix., p. 171.

An electro-magnetic separator mentioned by Rittinger consists of 14 vertical magnets, which are suspended to the bottom of a waggon that rolls forward and back over the endless feed-belt, and are united at the poles to a horizontal rectangular plate. While the pole-plate is swinging close above the ore-meal that is moving forward on the belt, the electro-magnets operate; but, on the other hand, their action is stopped by breaking the current as soon as the pole-plate, by reason of the advance of the waggon, gets beyond the edge of the belt, in order to let the magnetic ore-particles drop off. Unfortunately, as in many other communications of the above-named author concerning dressing-apparatus, he has not stated whereabouts the apparatus was made and how it worked in practice.*

A very simple magnetic separation-drum has been described by Johann Habermann, a pupil of Rittinger's, an inspector of stamp-mills at Przibram, in Bohemia, with which for a year and a half experiments have been made at the dressing-works there, with success, for concentrating zinc blende containing spathic iron.†

Through the use of permanent, steel, horse-shoe magnets, the electric-apparatus is rendered unnecessary. In a broad, conical, and short drum, made of wooden staves and open at both ends, having an outside rim by which it rotates upon friction-pulleys, the horse-shoes are so arranged that they lie, with both their poles, inside the inner surface of the drum, and so that neither depression nor projection is made therein, consequently both poles of each magnet are utilized. By means of the slow revolution, the magnetic grains of ore are collected on the magnet and remain hanging to it, till they reach a cylindrical brush at the top of the drum, which sweeps them off the surface of the drum, by a pushing and turning motion, upon an inclined table, leading to a receiver placed before the drum. The expenses, according to this account, are merely for the renewal of the brushes, which are said to last from two to three weeks.

The cost of an apparatus, 1·25 metres in diameter and 0·63 metre in length, with 48 magnets, is said to be 600 to 700 marks, and will work up 100 kilogrammes of ore-meal, of 1·5 millimetres size of grain, per hour, with $\frac{1}{10}$ horse-power.

The magnets have arms 315 millimetres long and 13 millimetres thick, with an interval of 52 millimetres between them, and cost 8·80 marks apiece. In the experiment at Przibram, spathic ore containing blende was worked up, after previous reduction and roasting.

Coal being at the high price of 18·40 marks per ton, the cost of 1 ton (1,000 kilos.) of ore worked up (1 florin being considered equal to 2 marks) is—

1. Crushing to 1·5 millimetres, grains	1·20	marks.
2. Roasting in a reverberatory furnace	6·00	„
3. Attendance for the magnetic apparatus	0·40	„
Total	7·60	„

The products thereby were 10 per cent. zinc blende and 90 per cent. spathic iron, from the values of which the profit per ton of ore worked up was reckoned at the high rate of 20 marks per ton. At any rate, the results appear to encourage further use of this apparatus.

With magnetic iron ore, which does not need to be roasted, the cost would be diminished to 1·06 marks per ton, or about a third only of the corresponding cost with the above-mentioned Sella machine. The apparatus would

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* P. von Rittinger, Second Supplement to his text-book *Die Aufbereitungskunde*, 1873, p. 77, Fig. 338. According to A. Henry, *Préparation mécanique à Przibram*, *Ann. des Mines*, 1872, 7e sér., tome ii., p. 292, experiments have been made at Przibram, in which 150 kilogrammes of ore were worked up per hour.

† Austrian *Zeitschrift für Berg-, und Hüttenwesen*, 1877, vol. xxv., p. 47, Plate II. In the same journal, 1874, vol. xxii., p. 9, an older patent magnet-machine by H. Simon, of Manchester, England, is mentioned, in which the magnets are arranged spirally on a roller, and which is said to be often used in machine-shops for separating iron filings from copper and other filings. The mixture to be separated is placed in a trough-shaped vessel, and therein is steadily pushed along by the ends of the magnets, while a brush-roller at the top of the magnetic roller sweeps off the attached iron filings.

probably also do very good service in purifying magnetic iron ore, containing apatite, for producing Bessemer pig-iron, nearly free from phosphorus, and at the same time to obtain the apatite, valuable as a manure, as a side product.

VII. HOISTING MACHINERY AND OTHER MECHANICAL AIDS.

1. Machines for pumping Water already used in Dressing.

In the mining districts, where water can be used at all, the obtaining the necessary supply is always a most important question, even under the most favourable circumstances. As a rule, it is inadmissible to let the waste water flow into the natural water-courses, on account of its adulteration by metallic slime, which is detrimental to vegetation, to fish-culture, and to the other uses of water.

The tailings must, therefore, after sufficient clarification in slime-pits (see Section VI.), be raised again by special water-hoisting machines to the storage basins of the dressing establishment. In setting up the machines for raising the dressing-water already used, three points are essential:

1. The constant and large quantity of water, which an economical arrangement in regard to efficiency and use of coal demands.
2. The usually slight difference of level between the settling-pits and storage-basins, and consequently, a small height of lift for the water-hoisting machines.
3. The disturbing influence of the slimy water upon the piston and packing of the pumps.

The so-called "special" steam-pumps, which, on account of their slow action and small service, are only suited for temporary purposes, and, for small quantities of water, do not answer the previous conditions, and, even where they were employed, have soon been replaced by better machines. Indeed, their horizontal position shows them unfitted for slime-water, on account of the unequal wear of the pump-piston.

The plunger-pump, placed in a vertical position, is therefore preferred to the piston-pump, and it is customary to drive it by the motor of the dressing-apparatus, which, as a rule, is economically managed.

Similar arrangements are used in Bérard's and Evrard's coal-washing works, and in the copper-dressing establishments at Lake Superior. P. von Rittinger recommends rotary pumps, which not only answer the above conditions (2 and 3) completely, but require a minimum of space, and on account of their rapid revolutions are driven most cheaply and simply by belts led from the rapidly revolving main shaft of the works, and have the additional advantage of a smaller first cost. With proper construction, the first condition can also be filled satisfactorily, by allowing no fall in the collection and discharge canals to be lost. Great care and cleanliness are, however, required in management, which can seldom be attained in ore-washing.

At the magnificent, large zinc and lead ore dressing-works, in Upper Silesia, in the place of piston-pumps they have bucket-wheels with iron rims and spokes of considerable size, constructed wholly or partially of iron, which answer the purpose excellently.

In the washing establishment at Scharley, near Beuthen, in Upper Silesia, such a bucket-wheel 13·81 metres in diameter and 1 metre in width, with a rim 0·5 metre high, has been at work for a number of years. This wheel, with a velocity of circumference of 1·5 metres per second, raises 4·25 cubic metres of water per minute, a vertical height of about 10 metres, measured from the water level of the upper ditch. The driving-engine works with a small pinion into a cast-iron cog-wheel bolted to the rim of the water-wheel. The pinion-shaft is set at the level of the shaft of the hoisting-wheel, and on the masonry forming its foundation. The total cost of construction, an old engine being used for motive-power, was 33,025 marks, the water-wheel alone being 26,726 marks. The cost of maintenance for a year was 1,550 marks, because only half the time of an engineer was needed, and very cheap coal, at 2 marks per ton, was used for heating the boiler.

At the new blende and lead ore dressing-works at Blei-Scharley, under the same management, such a wheel, of somewhat smaller dimensions, has been likewise used on account of the efficiency of the arrangement just mentioned.

More rapid wear takes place with the sharp-grained blende-slimes than with the zinc tailings, so that the sheet-iron buckets will last only about three years.

They have, therefore, set up a pulsometer there as a reserve apparatus, which, aside from its high consumption of steam, is said to do well.

The pulsometer has been used also at other Upper Silesian washing establishments, and has been found perfectly satisfactory from its capacity of working in a small space, and from its cheapness, and simplicity of construction and maintenance.

2. Elevators for raising the Material to be dressed.

Where it is possible, dressing-works are so arranged that the separate rooms, and the machines through which the material to be dressed passes during separate mechanical processes, lie under one another in terraces or stories.

Even where there is no natural inclination of the ground suitable for terracing, it is customary to adhere to the story construction, and preference is given to raising the raw material in the cars, as it comes from the mine, to the highest story, either directly by the shaft-hoisting machinery, or by means of special cranes, which are usually driven by the hoisting-engines, in order to obtain sufficient fall from apparatus to apparatus, and to wholly avoid, or, at least, limit as much as possible, the lifting of the middle products.

This is especially important where raw material in large pieces—as hard, lumpy ore—is treated, for that acts destructively on the interior of the vessels used in hoisting, or like coal, which is broken up in filling and emptying, and is thereby depreciated. In ore-mining it is unavoidable that certain middle products—ore to be rolled or stamped—must be carried from the works to the dump, temporarily, and be brought back from there at the proper time to be worked over. In such and in other cases, where there is an accumulation of material, and horizontal transportation cannot be avoided, apparatus for hoisting cars must be erected.

With cranes which work by means of ropes inclined planes are preferred,—partly, because they are less dangerous to the workmen, partly, because they are better adapted for emptying the filled and elevated cars automatically.

In hoisting vertically by a rope, it is better to make the apparatus in such a way that the cage hangs by two ropes, so that if one rope breaks the other may prevent its fall, and also in order that workmen standing near the car, on the cage, may control the hoist, and stop at pleasure at every story of the building without being compelled to stop the cage by the insertion of the so-called caps.

The arrangement of the hoist used by William Sellers & Co. at the Centennial Exhibition at Philadelphia, for the prospect-tower on George's Hill, will serve as a pattern in this respect. In fact, that one was regulated by means of belts and pulleys, and the transmission of power to the rope-drum was effected by an endless screw.

The hoist can be run by any transmission shaft of the dressing-works at pleasure, without having a special attendant for it. The cost of such an arrangement is small.

At the above mentioned Blei-Scharley works a similar hoist is used, in which the drum is moved by an endless screw.

Where there are water reservoirs at a higher level, hydraulic piston-lifts can be recommended, of which a good example, for a height of about 22 metres, was given at the Paris Exposition, in 1867; for lesser heights, a comparatively feeble water-pressure of 1 to 2 atmospheres is sufficient. Such piston-lifts can be arranged so simply that they are only guided by the attendants, and stop automatically at the end of their movement.* They have also the

* Opportunity was given to the author himself, a number of years ago, to erect rope-hoists, and also hydraulic piston-lifts, according to the system pointed out above, at the Government salt works at Schönebeck, which have answered the purpose very well.

advantage of the rope-hoists in their greater safety and economy of working. Besides, it appears important to place a directly-acting plunger-piston under the cage, and to balance it with chains and counter-weights, placed at the side of the cage. The weight of the chain is to be so adjusted that the difference of hydraulic pressure in the rise and fall of the piston shall be equalized.

M. Evrard uses a water piston-lift with his hydraulic classificator for lifting and pouring in the charge, in which a tip-tub, carried by the piston, in its lowest position, takes up the whole charge, and in its highest position empties it automatically into the hopper of the washing-apparatus.

Pneumatic elevators, such as have been used satisfactorily of late at blast-furnaces, have probably not yet been used in dressing.

In dressing, as a rule, elevators are used for raising the raw material, reduced to small-sized grains. They, however, require, in a measure, continuous action while the supplying and delivering of the material goes on, and therefore they are brought into direct connexion with the reducing, sorting, and washing apparatus. Special care is used in the construction, because otherwise the chains and buckets wear out very fast, and require troublesome repairs. Elevators are also used in coal-washing establishments, which scoop the material out of large bins, provided with inclined bottoms, or out of slime-pits, and are so arranged that, in working, certain irregularities in the supply and delivery of the materials are admissible. With the smaller resistance of coal this appears more allowable than with ore.

The elevator connected with a sorting-drum, constructed by Huet & Geyler, is a serviceable contrivance. The outer case of the drum forms the under sheave for the chain of the elevator, and is provided with discharge openings, which come over the cast-iron buckets as soon as the latter reach the drum-case with their corresponding hollow sides. A similarly constructed cast-iron drum, with a rim, serves for the upper chain-sheave, receiving the raised material and emptying it from the bucket. In this way the friction of the sharp ore-grains against the chain links, and the wearing away of the bucket edges, is avoided.*

The bucket chain (chaine à godets) serves, at the same time, for turning the sorting-drum, since the upper sheave is placed on the transmission-shaft.

As a pattern of an extensive and systematic use of elevators for the automatic working of very complicated dressing, the important copper pyrites dressing establishment, at Fahlun, erected by E. Heberle, according to Rittinger's principles, should be mentioned, because the terraced arrangement has been intentionally avoided there, and the advantage of uniting all operations in one building, easily inspected, has been attained with great skill.

For raising hard ore lumps or grains to a small height, lifting-wheels have also been used with advantage, in which the material to be raised is shaken into the rim of a wheel, provided with inside buckets, and falls from the buckets into a receiver at the top.

These wheels correspond, in prineiple of construction, with the cleansing drums provided with inner throwing buckets. These were used in the oldest rolling-mills in the Upper Hartz, and are sometimes employed usefully to this day. They are more durable than the elevators, but require more room.

3. Horizontal Transportation by means of Endless Belts, Screws, or Water-Pipes.

For moving the dry material continuously along from one apparatus to another within the building, horizontally or with a slight incline, endless belts are used, which are made of hemp webbing, leather, woven wire, or other suitable material, and run on rollers.

Screws are used still oftener than belts for transportation. The screw, lying in a wooden or metallic trough, requires considerable driving-power, on account of the friction of the forwarded grains, and is subjected to great wear.

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* A. Habets, *Préparation mécanique*, p. 586, and Plate VII., Fig. 1; P. von Rittinger, First Supplement to the *Lehrbuch der Aufbereitungskunde*, 1870, p. 72, Fig. 301.

In coal-dressing these inconveniences are diminished. The forwarding screw is, therefore, often used for coal slack. With moist and fine materials, this is preferable to the endless belt, because the latter scatters along the way the grains sticking to it.*

Hydraulic transportation in pipes has been used with advantage in the washing-works at Bleiberg, near Commern, for forwarding sandy tailings. Owing to the small amount of lead (only a few per cent.) in the raw material dressed there, very large masses of deads are carried from the washing-works to the dumps, which form quite a hill. This is done in long pipes. A strong stream of water sucks the waste of the washing-works into the conductor, and pours it out on the summit of the dump.

For sucking up the waste, the water-jet apparatus much employed of late in draining mines should be used. Steam injectors may be used with advantage for this purpose, so far as these can be adapted to circumstances,—like Körting's spout, for instance. The conducting pipes require only a small cross-section, even for very large amounts of material; nevertheless, in its arrangement, care must be taken to avoid short bends in the conductor. This hydraulic transportation can be employed in numerous ways, by use of the experience acquired in hydraulic gold-mining and in water-works.†

Under mechanical contrivances for transportation, the collection tip-boxes, first constructed by E. Heberle at the dressing establishment at Fahlun, still deserve mention. These were used for collecting and drying the tailings from the waste water, in order to diminish the precipitation in the slime-pits. The coarser portion from the waste water, raised by an elevator, goes into these tip-boxes, and is emptied from them into large forwarding-cars, which are taken to the dumps by forwarding-ropes.

4. Picking Arrangements.

The labour of picking or culling (in Upper Silesia called *Klinseln*, in Austria *Kutten*) was formerly done by hand only,—partly in connexion with breaking up the sorted gangue, partly after the cleansing of the smalls. In the latter case, the coarse pieces of mineral, too large for jigging, were emptied upon stationary tables, and there separated by children, by hand-picking, into deads and various sorts fit for further dressing. At coal mines, which, of late, are almost everywhere provided with screening arrangements, the inclined screens afford an opportunity to the pieces of slate sliding over the finer bar-screens to become separated from the cube and lump-coal without further arrangement.

M. Evrard, in 1852, at the frequently-mentioned Chazotte Mine, near St. Etienne. in laying out his ring-jig, made use of a rotary picker and screener.

All the coal extracted from the beds, except the largest pieces, which are previously separated in the mine, is thrown by three adjacent tip-cars, standing over a common hopper, upon a rotating cast-iron feeding-disk, and pushed from this by a fixed scraper-plate upon a ring-shaped iron grating, with spaces of 12 millimetres between the grate bars. This grating, 1 metre wide and 7 metres in diameter, retains the cube-coal, and serves as a picking-table. Under it there is a ring-sieve of the same shape, with 5 millimetres width of mesh, which retains the nut-coal, and lets the slack fall upon a ring-shaped disk-plate, which lies below. In the inside of this horizontal ring there is an annular space between two concentric, vertical, sheet-iron cylinders, and this is divided by vertical, radial, sheet-iron walls into numerous compartments. Half of these compartments are provided with a floor of such width and depth that a boy standing therein, may be at the right height to command the top of the picking-table which lies before him.

The other half of the compartments, alternating with the former, are open

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* P. von Rittinger, Second Supplement to the *Aufbereitungskunde*, 1873, p. 80.

† In the pneumatic foundations of the bridges over the Mississippi at St. Louis, and over the East River at New York, this method of transportation has also proved excellent for forwarding large masses of coarse gravel.

below. The openings are over an iron annular disk which receives the pieces of slate picked out by the boys, and tossed into the open compartments.

Since the picker-boys move round in a circle, with the picking-stuff spread out before them, it lies steadily in range of their eyes during a whole revolution of the picking-table, and they are thereby aided in rapidly finding and picking out the pieces of slate.

The material remaining on the disk is kept in motion by several stationary rakes, and, at the proper place, is scraped off continuously,—partly into collecting-boxes, partly into forwarding-cars placed underneath; while only the nut-coal, of 5 to 12 millimetres size of grain, from the second disk from the top is led to a small percussion-screen with round holes. This operation serves for sifting the flat pieces of slate which have fallen through the grating of the picking-table, mechanically, from the nearly cubical nut-coal.

According to Evrard's statement, a picking and screening table of this kind is said to be able to work up 100 tons of coal per hour.

In ore-dressing, simple disk-shaped picking-tables are used, which rotate about a vertical spindle, while the workmen stand around the table and pick out the valuable pieces of mineral from the raw material, which is thinly spread out, and slowly passes before their eyes; and at the same time, also, they separate it into several kinds,—sorted gangue, crushing ore, stamping ore, or even into further classes, to be worked over separately.

Sometimes each workman has the picking out of a distinct sort assigned to him, and a contract made according to the amount of metal contained in it.

By this plan the pieces of mineral which form the greater part of the stuff,—the deads,—are left. But it may also happen, with very rich ores, that the deads form the smaller portion, and are picked out. The portion left lying on the disk is shoved mechanically by fixed scrapers into forwarding vessels placed underneath.

At the Paulus coal mine, in Upper Silesia, rotary picking-tables are used, which have two concentric ring-disks. The inner one, which is somewhat the higher, is used for picking out the nut-coal, while the cube-coal is picked on the outer disk.

With the endless picking-belts, the mode of working is the same. At the Blei-Scharley Mine an endless picking-belt is used, woven of iron wire, after the fashion of a shirt of mail, with a breadth of about 1 metre, and an available length of 7·5 metres, and it moved with a velocity of about 9 metres per minute. There are tracks on both sides for the cars used in carrying off the deads picked out. Over the picking-belt there is a suspended track, on which are small hanging vessels for receiving the lead ore. The gangue, containing ore, is taken by the belt directly to the rollers. The belts last about three months. On account of the complicated mechanism and wear of the belts, the rotating-table is usually preferred.

5. Means of Transmission.

The great number of apparatus for reducing, sorting, concentrating, and mechanically moving the masses to be dressed, demands a complicated mechanism in order to convey driving-power from the chief motive agent to the separate parts of the machinery with the desired velocity.

In place of the former clumsy, slowly-turning shafts and gearing, may now be found nearly everywhere quickly-revolving iron counter-shafts with driving belts. Since most of the apparatus requires quick motion, and the working capacity of a counter-shaft, or of a belt, increases in proportion to its rate of speed, it is essential to make this rate as high as possible.

With increased speed, therefore, greater accuracy is necessary in setting the journals of the shafts, as well as in their technical construction. The European establishments have not yet reached the point of perfection in this respect that obtains in the United States in the building of machinery. William Sellers & Co., of Philadelphia, for example, give to their shafting for wood-working machinery 250 revolutions per minute.*

* In fact, spinning machines from this establishment are capable of making 300 to 400 revolutions per minute.

For that reason the shafts are made exactly cylindrical by turning, so that the belt-pulleys may be shifted at will, according to the various positions of the apparatus to be driven. Belts of hemp webbing covered with india-rubber have been much used of late in place of leather ones.

Horse-hair belts, too, notwithstanding their high price, have proved to be excellent, on account of their durability, but they do not bear crossing. The arrangement of dressing-works seldom requires a transfer of motion by means of a single counter-shaft, nor is it advisable tc give this too great a length.

The wire-rope transmission used by Hinn in the wet-dressing works at Mülhausen offers, therefore, great advantages, when, for instance, the power is to be transmitted to a distance of 30 metres or more. E. Heberle, at the Fahlun dressing work, has used this method with favourable results.

For the transfer of working forces of minor power, such as are used with most of the dressing apparatus, small cotton cord, or even hemp rope of moderate size, is to be preferred to wire rope. These demand a great velocity, but, on the other hand, on account of their lightness and flexibility, allow a much greater variety in placing the shafts, are much handier, and also cheaper to maintain than belts, and cause no such inconvenient obstruction as the couplings of wire rope do. It appears, however, that this improved mechanism has not yet been brought into use in dressing operations.

VIII.—GENERAL REMARKS.

I. Architectural Arrangements and Construction of Works and Conducting the Business.

In the architectural arrangement of dressing works, the introduction of rolling-mills into England, in the beginning of the latter half of the present century, brought about decided advances by rendering possible a concentration of higher skill combined with the aid of machines, together with a corresponding disuse of hand-separation, and by settling upon a suitable division of the working space for the crushing-stuff and the small-stuff.

The introduction of more efficient purifying- and sorting-drums, as well as that of the mechanical jig, at the Upper Silesian, Rhenish-Belgian, and Hartz dressing establishments, required the employment of more powerful engines, and a concentrated, easily-overseen disposition of the numerous apparatus moved by them.

The starting points of the advance at that time were the plane-tables of Von Carnall (afterwards mining superintendent), made for the government dressing works of the Friedrich Mine, at Tarnowitz in Upper Silesia, and for the Altenberg Joint Stock Company (Société Anonyme de la Vieille Montagne), at the Altenberg calamine mine, at Moresnet, near Aix-la-Chapelle. The numerous dressing works of the company afterwards built on the Rhine, in Belgium, at Immekeppel and Steinenbrück, near Bensberg; Silberband, near Mayen, and at Welkenrädt, in Belgium, under the intelligent guidance of mining-director Max Braun, at that time their chief engineer, gave opportunity for comprehensive experiments and a new order of arrangements. The theoretical principles of Von Sparre and Von dem Borne here found practical application, and led to the use of the classificator for coarse, mealy stuff, with an ascending stream of clear water, and to the employment of the Upper Harts pointed-trough.

The use of Rittinger's pointed-box for sorting and condensing tough slimes in Austrian Hungary, exerted considerable influence also.

Since the old German long labyrinth sluices, with their middle products, requiring frequent handling, had been given up, the tailings from the purifying drums, rollers, and stamps were sufficiently condensed in the before-mentioned compact sorting apparatus, in order to convey them to the concentrators in a steady flow through correspondingly short launders. The automatic co-operation of these machines with the reducing- and sorting-contrivances was at the same time arrived at for dressing sands, or mealy stuff, and, in addition to the great saving in wages, a closer combination of the apparatus in a smaller space was rendered possible. Hand-in-hand with it went the

improvement in the jigging-machines, in respect to the automatic delivery of the jigged products by the use of iron in construction (suggested by Bérard, Carnall, and others), whereby the operation of continuous jigging on an ore-bed, employed for coarse sands, hitherto washed on table, led to a complete overthrow of the fundamental plan formerly pursued. The work of laying out dressing-works and preparing the apparatus and contrivances needed in them, should, according to the principles of a division of labour, be a special field for the civil engineer and machinist, under whose skilful fashioning the earlier clumsy and perishable wooden tools and machines have been changed, even in the smallest details, into handy, durable, and serviceable apparatus, systematically combined for working up large masses of material automatically.

This turning-point was clearly recognizable, even at the Paris Exposition in 1867, although the reform was then only in its first stage of development. The frequently-mentioned essay of Habets denotes the state of things in the very building plans shown there for the new Central Washing Works at Clausthal, at that time only just projected. The account is completed by Henry's excellent travelling notes upon the dressing establishments in Belgium, in the Rhine Provinces, and at Przibram, in Bohemia; by the special articles upon the dressing establishments at Steinenbrück, near Bensberg on the Rhine, and at Scharley in Upper Silesia, in Schönfelder's compilation,* by Evrard's thoroughly discussed papers upon his coal-washing works; and finally by the text-books of Gätzschmann and Rittinger.

In the old fashioned dressing-works there stood endless rows of jigs; large rooms were filled with all kinds of washing-tables, and a great crowd of workmen busy everywhere in attending the separate apparatus, and transporting the various products forward and back on extended tramways.

Habets proves, nevertheless, that the primitive, old, English dressing system, which depended principally on hand-labour, and at that time in use at Stolberg, near Aix-la-Chapelle, competed economically and successfully, especially in its results, with the dressing-works of the German system, which were filled with machinery.

In the magnificent dressing establishments erected during the last ten years, the automatic working of ores and coal seems developed to a high degree of perfection.

The Central Washing Works at Clausthal and the stamp-mills at Lake Superior present excellent samples of the use of hill slopes for the terrace system of arrangement. The cleansing of the small stuff by a previous breaking up of all the lumps by means of stone crushers and stamps takes place at the top; farther down come the reduction of the larger crushed stuff by coarse rolling-mills, and the picking out and rough jigging of the coarse jig-grains; still lower down, the further reduction of the disseminated ore in fine rolling-mills, the sorting of the finer sands and meals in drums, hydraulic classificators, and automatic fine grained jigs, in closest connexion therewith.

On the lowest story of the terrace system are the stamps for the very finely disseminated gangue from the jigs, together with their meal classificators, system of pointed boxes, meal-jigs, and a comparatively limited number of percussion-tables and rotating round-buddles.

With finely-disseminated ores, as at Lake Superior, the coarse and fine rolling-mills are usually left out of the system described, because such ores after the previous breaking up of the heavier pieces, are taken directly to the stamps. For ores very finely disseminated, table-shaped washing-apparatus is used, only exceptionally, for the concentration of the greater portion of the ore, as in the before-mentioned Sardinian ores worked up in Belgium, or for the California gold ores. As a rule, the materials to be dressed, whether ore or coal, go to the continuously-working jigs, and only a comparatively small portion of them—the tough slimes—are treated on tables.

Where the location is unfavourable to the terrace construction, as at the magnificent Meinerzhagen-Bleiberg works, near Commern, in the Eifel, and

* Schönfelder, *Die baulichen Anlagen auf den Berg-, Hütten-, und Salinenwerksen in Preussen*, published as a supplement to *Der Zeitschrift für das Berg-, Hütten-, und Salinenwerksen*, 1861-63, vol. ii., p. 1., Plates I.–IV.; vol. iii., p. 17, Plates I.–IX.

at the new blende and lead ore washing works of Blei-Scharley Mine, near Beuthen, in Upper Silesia, the arrangement in several stories over one another is used with success.

In these, the preparatory operations of washing the stuff to be jigged take place on the ground-floor, exactly in the same way as is done in the terrace construction on the upper story. Only small quantities of disseminated gangue from the jigs and the fine meals are raised by machines, in order to be again reduced, or are led through the pointed-troughs to the fine jigs.

As an example of a compact but roomy arrangement of the story system, and of high working capacity, the dressing-works at Blei-Scharley may here be considered more closely.

The massive main building is 10 metres broad, 22 metres long, and contains in its four stories, the uppermost of which projects about 12 metres over the ground-floor, the apparatus for working up the granular products. The driving-engine and boiler are in a side wing of the main building. The slime-washing works, in a second wing, have an elevator-wheel for raising all the tailings coming from the main building, also a system of pointed-boxes for condensing it, with four continuously-acting meal-jigs, of four divisions each, annexed thereto, for working up the condensed tallings. The tailings from the pointed boxes go back to the jigs.

The uppermost story is used for pouring the smalls into the cleansing drum, whose hopper is covered with an iron grating, which allows only pieces less than 70 millimetres diameter to fall through it.

The coarser pieces remaining on the grating, together with the lump ore from the mine, are carried to the rock-crusher, which stands close by it, and, after being broken to the size of 25 millimetres, are likewise lead to the cleansing-drum by means of a forwarding-screw. On the opposite end of the same story, and in an attic built especially for them, are the winding-drums of a car-lift, which is moved by an endless screw, driven by a belt, and which forms the means of transportation between all the stories. The cleansing drum allows the fine grains, together with the tailings, to fall through holes five millimetres wide made in the ring-shaped face-plate, through a vertical trough to one of the two fine sorting-drums, and forwards the larger grains into the coarse sorting-drums, which are extensions of the others.

The latter pour their product, consisting of grains of from 25 to 70 millimetres diameter, upon a woven-wire picking-belt, from which the deads and and the pure pieces of ore are picked, while the gangue containing ore falls from the belt into a system of forwarding screws, which carry it to one of the three rolling-mills.

Each drum yields three sorts of grains of from 5 to 8, 8 to 15, and 15 to 25 millimetres diameter. Each of these is led directly to a coarse-grained bed-jig of two divisions, which is only for the purpose of removing the deads as skimmings, and to consecrate the ore-gravel into two sorts, which are further reduced in two of the rolling-mills placed lower down, and are sorted in the two fine sorting drums. In these the meal and the slime tailings are next separated by a ring-shaped face-plate, with holes 2 millimetres wide, in order to be further sorted in the two stream classificators belonging to them. The drums yield as siftings, grains of 3, 4, 5, 6·5, and 8 millimetres diameter.

Each drum division pours its grain-sort into a special Hartz bed-jig of 4 divisions. These jigs yield galena in the first division, and blende in the three following divisions. The tailings, consisting of dolomite, fall directly into the trough-shaped tip-cars. The product of the sorting-drums falls into a similar car, and is again taken to the rolling-mills by means of the lift.

Hand-labour is, therefore, limited to picking, attending the jigs, and the transportation of the several products to the storehouse and the dump. In other respects, the process of dressing goes on automatically, especially by free-fall in the dressing apparatus itself. The number of mechanical contrivances for horizontal transportation and raising of the minerals is the smallest possible. The rather too great economy of space in the works on the one hand, and on the other the direct transfer of the products of

the rough-jigs to the rollers, which become overburdened at times, have proved disadvantageous. In the latter respect, the gathering of the products in sorting-boxes, and the regulating of the feed by hand, are to be recommended.*

Attention should be drawn to the important dressing-works at Stora Kopparberg, near Fahlun, in Sweden, built by E. Heberle, in 1868–70, as being the most prominent achievement in the way of ingenious arrangement and automatic, closely-connected mechanical contrivances upon a horizontal plane, for diminishing hand-labour. The character of the ore,—for the most part poor finely disseminated copper pyrites, containing but little gold— here presented uncommon difficulties, and, in the arrangement of the works, required numerous separations according to the contents of the ore to be worked up, by the employment of a great many washing tables, especially Rittinger's side-blow percussion-table.

In regard to details, reference must be made to the thorough and excellent description of this establishment as well as the principles there followed, and the practical working of the same, published by the builder in 1872, in Vol. xxxi. of the *Berg- und Hüttenmannische Zeitung;* for the space here given permits of only a hasty sketch of this master-work in its general outlines.

This extensive concern, consisting of three horseshoe-shaped one-story buildings connected together, is built with massive double walls, inclosing a stratum of air for protection against the severe cold of winter, besides being provided with double windows, and having the spaces between the rafters sheathed with boards and filled with sawdust.

The working up of the poorer smalls and the richer gangue follows in separate apparatus, which are systematically arranged in the building. The rock-crusher, rollers, and stamps, as well as the cleansing and sorting-drums, and the continuously-acting jigs, are set up in the middle chamber, in such a way that the reducing and cleansing machines, together with the first sorting-drums and rotating picking-tables lie in a row, while the wings on both sides are occupied by the stamp batteries. The middle and fine grain sorting-drums follow in a second row, with their proper system of elevators, and the jigs stand in a third row. This chamber is 83·6 metres long, 16 metres wide, and 6 metres high.

Similar apparatus are, for the most part, so arranged in pairs, near each other, that the members of each pair can be worked together or alone, alternately.

In the stamp-mill every 10 or 20 stamps are always connected with the motive-power by separate transmission ropes or belts.

In case of rapairs, therefore, or of lighter work in any place, the separate apparatus and machines can be stopped without interrupting the progress of the other work in any way.

The large lumps of ore from the mine and the picking-tables are loaded into cars by a crane, and are carried away on tramways above the tie-beams of the roof to the cleansing-drums, rock-breakers, rolls, and stamp-mills. The granular stuff from these is raised by an elevator to the sorting-drums, and then runs through a series of coarse-grain drums and one of fine-grain drums, placed in a row close to them; so that this process of sorting requires two elevators working together. The drums lie high enough to empty the sorted gravel directly into the jigs. By this means, great steadiness in feeding the jigs is also secured.

The two wings of the building serve for working up the richer and poorer stamp-meals separately. Each wing is 58 metres (195 feet) long, and 24·4 metres (82 feet) wide, and consists of two rooms. The room lying nearest the main chamber contains the side-blow percussion-table, with the classificators (Spitzlutten) belonging to it, for working up the sandy meals; the compartment lying farther off contains the rotating convex-buddles, with the large pointed-boxes pertaining to them, for working up the tough slimes.

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* The author is especially indebted to Herr Kunitz, director of the mining works at Scharley and Blei-Scharley, for his obliging and extensive communications upon the condition of dressing there.

The pointed-troughs and pointed-boxes lie so high that the condensed slime therein is conducted directly to the washing-table. The slime from the cleansing-and-sorting-drums is condensed in special, funnel-shaped settling-apparatus, and then, in company with the tailings from the stamps and the waste from the fine-grain jigs, is raised by a special elevator to the pointed-troughs and pointed-boxes. The refuse from the side-blow percussion-table is subjected to a further process on continuous plane-tables, and the copper contents are thereby reduced from 0·8–1·2 per cent. to 0·3–0·4 per cent., and then, after condensation in funnel settlers, is raised by an elevator to special tip-cars, by means of which it is more conveniently discharged upon the dump.

2. Range of Hand-Labour; Dressing Costs and Losses.

The important advances in mechanical dressing, at least in diminishing the amount of hand-labour, loss of ore, and cost in the modern establishments as compared with the older ones, can be proved by figures. Yet technical literature presents only unsatisfactory statistical data for a true comparison. It is also to be observed, that with the recent perfection of practice, large masses of poor ores have been brought to the dressing-works, which formerly went to the dump as worthless, and that as the expenses, and, more especially, the loss in working poor ores is wont to be higher, the results of the present time cannot be brought into comparison with earlier ones, without a consideration of all accessory circumstances. Nevertheless, it is worth while to present a few examples here. A. Habets mentions in his often quoted report upon the Paris Exposition (p. 627), that at the Breinigerberg Mine, at Stolberg, near Aix-la-Chapelle, comparative experiments were made, in 1860, between the German and English methods in use at that time.

These experiments gave per ton of similar zinc and lead ore, composed of 199 kilogrammes zinc, 107 to 109 kilogrammes lead, and 642 to 672 grammes silver, in ore extracted by the German method, 369 kilogrammes; by the English, 430 kilogrammes of pure product. The blende, by the former method, contained in the jig-gravel 38·2 per cent. zinc and 10·1 per cent. lead; in the slich 35·1 per cent. zinc and 12·3 per cent. lead; by the latter method was obtained in the jig-gravel 36·5 per cent. zinc and 9·92 per cent. lead; and in the slich 36·6 per cent. zinc with about as much lead.

The galena, by the former method, contained in the gravel 5·4 per cent. zinc and 73·9 per cent. lead; by the latter method 6·78 per cent. zinc and 70·42 per cent. lead.

The yield of metal has been accurately determined by weighing and assaying the ore obtained after working up, and the loss of metal in dressing by the German as compared with the English method was—

	German.		English.
In zinc	43·45 per cent.	in contrast to	43·20 per cent.
„ lead	56·66 „	„	33·61 „
„ silver	71·63 „	„	61·65 „

In experiments which were made in 1865 and 1866, at ten of the most important zinc-washing works in Upper Silesia, the loss of metal in the tailings, varying with the amount of zinc in the ore dressed, was, according to an unpublished paper by Frief (mining assessor and inspector of manufactures), deposited in the records of the chief mining office at Breslau, as follows:

Zinc in Ore.	Loss of Zinc.	Waste.
5 per cent.	85 per cent.	92·7 per cent.
7 „	73 „	86·3 „
9–10 „	34·4–50·5 „	62·4–40·3 „
12 „	36·6–47·4 „	66·4–67·4 „
15 „	28·4 „	48·7 „

The average amount of zinc produced in this case was only from 14 to 24 per cent.

The new dressing-works at the Blei-Scharley Mine—whose blende department has been described above in section 1—produced in the year 1876—

a. In the blende works, from	34,260	tons of raw ore	16,020	tons blende and	293	tons lead ore.
b. „ calamine „	20,592	„ „	8,167	„ zinc „	618	„ „
Total - -	54,852	„ „	24,187	„ „ „	911	„ „

that is, from 1 ton raw ore, 441 kilogrammes zinc ore and 166 kilogrammes lead ore.

These works, without the boilers, cost 320,000 marks. Reckoning the total cost at 400,000 marks, the annual outlay of 15 per cent. for repairs and sinking-fund amounts to 60,000 marks, or 1·09 marks per ton of crude ore.

The running expenses in 1876 were—

For wages - -	96,510 marks,	or 1·76 marks	per ton of raw ore.
„ coal - -	5,594 „	„ 0·10 „	„ „ „
„ repairs - -	12,000 „	„ 0·22 „	„ „ „
Total - -	114,104 „	„ 2·08 „	„ „ „
Add interest and sinking fund -	60,000 „	„ 1·09 „	„ „ „
Giving a grand total of - -	174,104 „	„ 3·17 „	„ „ „

According to Kunitz (*Baul. Anl.*, iii. p. 36), the running expenses of the washing establishment at Scharley, in the last quarter of 1863, were 0·952 mark in the calamine department and 4·43 marks in the lead-ore department, with an average of 1·24 marks per ton of crude ore.

According to Frief (as before mentioned), the cost of dressing in 1866, at the very important mechanical calamine-washing works in Upper Silesia, was to each ton of crude ore washed, including transportation to the works, almost uniformly 1·50 marks, and further, that in 1860 at one of the washing-works of the Elizabeth Mine (built by him in 1859),

The dressing costs were - -	1·035 marks.
Interest and sinking fund - -	0·383 „
Total - - - -	1·418 „

In comparing these figures with the Blei-Scharley ones above, we must, however, consider that the blende ores dressed at the latter place are considerably more difficult to work up, on account of their hardness and intimate mixture with galena, than the calamine, mixed with clay and soft dolomite, which was formerly the only kind washed there, and, further, that, through the application of jigging to the gritty meal of the tailings, the former very considerable loss of metal, both lead and zinc, has been considerably diminished.

In general, it appears in these comparative experiments at the Upper Silesian calamine washing-works, that the cost of dressing a ton of crude ore varies very little, even taking into account the differences in the pure ore contents, under the similar conditions existing there. Unfortunately, the figures for an explanation of this advance are wanting in the older accounts respecting the amount of crude ore manipulated, and the number of workmen employed.

According to the before mentioned communications by Heberle upon the Fahlun dressing establishment, in the fiscal year of 1870–71 were worked up there 194,265 Swedish centners of crude ore, containing 2·889 per cent., or a total of 5,612 centners of copper, and therefrom were obtained 55,005 centners of smelting-ore with an average of 8·17 per cent., or a total of 4,494 centners of copper. The loss in dressing, with a 2·84-fold concentration, was therefore 19·92 per cent. of the metal contents.

In these operations, 57 workmen and 3 foremen, in all 60 men, were employed. So that the yearly product per head is 3,408 centners of 42·5 kilogrammes each, or 145 tons of dressed ore.

The special dressing expenses in the way of wages and superintendence are, on the average, 0·291 marks per centner of smelting-ore; that is, according to the above proportion, 0·291 : 2·84=0·1025 mark per centner of crude ore, or 2·41 marks per ton of same. Wages were only slightly higher than at Blei-Scharley, in spite of much more difficult circumstances.

In the statistics concerning the management of the Quincy Mining Company, published in the technical journals of the Lake Superior copper districts, the following noteworthy figures are given of the results in 1870 and 1871 of the dressing-works of this company at Hancock, in which the ordinary Cornish stamps are used:

Crude ores stamped* - -	55,027 tons.	67·112 tons.
Average copper-contents - -	2·61 per cent.	2·61 per cent.
Working days in the year - -	283	292½
Cost of stamping and washing per ton - - - -	$2·15	$1·085

According to C. M. Rolker,† at the dressing-works of the Atlantic Mine at Houghton, Lake Superior, where 3 Ball stamps and 56 jigs are used and 53 workmen employed, 80,000 tons (72,576 metric tons) of crude copper ore were dressed during the working year of 1875–76; that is, about 1,369 metric tons to each workman per year, or nine times the above-mentioned capacity of the Fahlun works. This very much greater capacity, as was confirmed by that author on the spot, is due to the working up greater masses at once and to the simplicity of the process required for dressing the specifically heavy native copper.

The amount of coal used in 24 hours was 14½ tons, at $5·00; of oil, 1 barrel (45 gallons) in two weeks, at $45·00 per barrel. In the same report is given the following table of figures (here reduced to the metric system), compiled from reliable returns, to show the economical results of some of the Lake Superior stamp-mills for the working year of 1875–76:

Name of the Mine.	Kind of Stamps.	Quantity of Stamped Ore.	Yield in Washed Copper.	Yield in Metallic Copper.	Average Contents of Copper in the Washed Copper.	Stamped Ore to One Cord of Wood.	Cost of Dressing per Metric Ton of Crude Ore.	
		Metric Tons.	Per cent.	Per cent.	Per cent.	Metric Tons.	Dolls.	Marks.
Allouez -	Ball	46,389	1·83	1·40	76·25	?	1·19	4·46
Atlantic -	„	72,576	1·36	0·99	71·92	12·69‡	0·97	3·64
Franklin -	„	53,472	1·27	0·99	77·92	9·83	0·86	3·23
Central -	Cornish	15,529	3·78	2·68	70·82	9·25	0·95	3·56
Quincy -	„	63,958	?	2·44	?	11·32	1·07	4·01
Phœnix -	Atmospheric	72,576	1·36	0·98	71·93	?	0·97	3·64

From this table, the cost of dressing appears about 1·5 to 2 times as high as in Upper Silesia and Fahlun. The monthly wages of a washer in Upper Silesia are from 20 to 40 marks, varying with the age and sex; or scarcely a quarter of the pay given at the stamp-mills of Lake Superior, just quoted. If the considerably higher cost of materials there be also considered, the results of the above table appear extremely favourable. Another important advantage is, that all the tailings of the stamp-mills pass off with the waste water into the lake, without further expense.

* At Lake Superior 1 ton = 2,000 lbs. = 907·2 kilogrammes.

† *The Engineering and Mining Journal*, 1877, vol. xxiii., p. 335. There are 12 workmen for handling the ore, at $40·00; 8 firemen, at $47·00; 2 foremen, at $70·00; 2 machinists for repairs, at $55·00; 1 smith, at $60·00; 2 copper cleaners, at $70·00; 18 boys, at $25·00 in the main works: also 1 washer, at $70·00; and 5 boys in the tail-house, at $25·00 per week; that is, 47 hands in the main work, and 6 in the tail-house, making a total of 53 workmen.

‡ Stamped ore to 1 ton (2,000 lbs.) coal.

The loss of the metal in dressing is certainly very large there, and arises partly from the floating copper-scales, and partly from finely-disseminated copper-particles in the coarse tailings. It is owing to this that, at the Atlantic washing-works, the tailings from the jigs still contain 0·84 to 1·36 per cent., and those from the convex-buddles 0·78 to 0·90 per cent. of copper.

These works consume 8,316 litres of water per minute, or to each ton of crude ore stamped 41·35 tons (cubic metres) water in 24 hours.

Unfortunately, European ore districts present no such regular statistical publications of working results for comparison.

3. Statistics concerning the use of various Apparatus and the Number of Workmen.

The advance in the art of dressing may also be shown, in a characteristic manner, by a statistical comparison of the number of apparatus and workmen employed therein, so far as the mineral products of certain ore districts or countries may be considered. Although similar facts of earlier times are wanting, the more recent statistics, nevertheless, present a proper means of estimating the technical stand-point reached.

E. Heberle gives the following inventory of apparatus at the copper washing-works at Fahlun, in 1870–71: 32 stamps, 2 rock-breakers, 1 set of rolls, 30 sorting-drums, 6 pointed-troughs, 2 pointed-boxes, 6 conical separators (for condensing the tailings), 25 hydraulic continuous-jigs, 4 rotary convex-buddles, 6 Rittinger percussion-tables, 13 continuous plane-tables, 15 elevators, and 1 crane.

The working force was 60 workmen and foremen.

The general mining statistics of the kingdom of Prussia, of Dec. 1, 1875, gave the following apparatus in use:*

1. *At Coal Mines:*

2 rock-breakers, 9 sets of coarse rolls, 24 sets fine rolls, 19 Schleudermühle, 8 cone-mills, 2 muller-pans, 189 sorting-drums, 34 percussion-screens, 1 slime-separator, 13 sets of pointed-boxes, 226 continuous hydraulic-jigs, 26 not continuous, and 10 other jigs, and 3 rotary buddles.

2. *At Lignite Mines:*

10 sorting-drums and 55 percussion-screens.

3. *At Iron Mines:*

2 stamp-mills, 45 stamps, 8 rock-breakers, 6 sets of coarse and 5 of fine rolls, 60 cleansing and sorting-drums, 1 percussion-screen, 3 slime-separators, 5 meal-classificators, 1 set of pointed-boxes, 26 continuous hydraulic jigs, 46 not continuous, and 2 other jigs, 2 round-buddles, 4 rotary-buddles, 6 common and 2 Rittinger percussion-tables, and 15 plane-tables.

4. *Ore Mines:*

98 stamp-mills, with 1,721 stamps (26 of them for dry work), 68 rock-breakers, 100 sets of coarse and 115 of fine rolls, 1 muller-pan, 968 cleansing and sorting-drums, 11 percussion-screens, 67 slime-separators, 95 meal-classificators, 160 sets of pointed boxes, 1,714 continuous hydraulic jigs, 440 not continuous, and 138 other jigs, 221 round-buddles, 162 rotary-buddles, 90 sweeping-tables, 153 common continuously working percussion-tables, 35 of Rittinger's and 25 others, and 99 plane-tables.

5. *In other mining:*

4 rock-breakers, 2 coarse rolling-mills, 1 Schleudermühle, 14 cone-mills, 27 muller-pans, 8 cleansing and sorting-drums, 39 sweeping-tables, 183 plane-tables.

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* *Zeitschrift für das Berg-, Hütten-, und Salinenwesen*, 1876, vol. xxiv., Statistics, p. 229.

These figures gave further a statement of the number of workmen and of the kinds of motors, with their respective horse-powers.

For obtaining	Workmen, including Foreman.		Vertical Waterwheels.		Turbine and Tangent Wheels.		Stationary Steam Engines.		Portable Steam Engines.		Total Horse-power of Motors.	
	Male.	Female.	No.	Strength.	No.	Strength.	No.	Strength.	No.	Strength.	Water.	Steam.
Coal - -	2,017	260	—	—	—	—	130	2,417	25	270	—	2,687
Brown coal * -	731	65	—	—	—	—	110	2,392	1	29	—	2,421
Iron ore - -	1,831	127	8	41·5	—	—	9	174	4	43	41·5	217
Other ores -	6,369	2,104	98	698·0	20	550	125	3,018	20	224	1,248·0	3,242
Other minerals	481	—	—	—	—	—	12	241	—	—	—	241
	11,429	2,556	106	739·5	20	550	386	8,242	50	566	1,289·5	8,808

* In the number of workmen and steam engines here given, seem to be included the men and machines employed in making the so-called briquettes (Press-steine), which manufacture is limited, in Prussian coal-mining, to certain bituminous coal mines only, but form one of the most important means in brown coal mining for bringing the heavier, moist, gravelly coal into market.

The improvement of the dressing processes at the Prussian mines, both in their separate branches and as a whole, is shown by the ratio of hands there employed to the total number of miners. On the 1st of December 1875, this was: in the mining of hard coal, 1·42 per cent.; of bituminous coal, 4·15 per cent.; of iron, 11·16 per cent.; of ore, 24·26 per cent.; of other kinds, 8·77 per cent.; in mining generally, 5·89 per cent.

The advance of technics will probably be marked by the formation of suitable statistical tables of working results in the important mining districts, as a common necessity for the further development of the art of dressing, and, supported by the public spirit of a technical union, everywhere busy, will lead to the collection of material for a comparative statistical review of actual results, as has been customary for a long time in other branches of mining and metallurgy. The adoption of the metric system of weights and measures, begun in the United States, and already introduced into the most advanced countries of Continental Europe, will facilitate the rapid survey of the state of progress or want of it in individual countries.

Breslau, Dec. 1877.

COAL-MINING MACHINERY.

By Achille Jottrand.

The vast coal fields which enrich the United States are chiefly near the surface. The different basins composing the same are crossed by numerous valleys of erosion, and the strata appear on the sides of the hills. The greater part of the mining is therefore done in horizontal galleries above the level of the valley, or in slopes dug into the vein from the surface. The beds are generally thick, free from choke-damp and deletereous gases, and consequently the mining of coal is not subject to the many difficulties encountered in most of the European mines. Up to the present time no underground waters have been met with, the crossing of which always involves great expense. The installation of perfect machinery for extraction, working with rapidity and economically, and adapted for very deep mines, is not required in the United States, where the extraction through galleries or from a slight depth will suffice for many years to come. The mining as it is done in the United States does not require the same system of lighting, ventilating, and transportation, which is absolutely necessary in other countries for the protection of the miners' lives. The almost complete abstention of the United States from exhibiting mining machinery was no doubt to be attributed to this fact.

On the other hand, Europe exhibited but a very small number of mining machines and apparatus. The distance, and the difficulty of transportation and erection, caused the foreign representatives of this industry to abstain from displaying their machinery; besides, they could count but little upon the application of their systems to American mining.

Coal-cutting Machines and Mechanical Coal Separators.

The idea of effecting mechanically the separation of the coal from the inclosing rocks originated in England. This country is almost the only one which pursues the study and perfection of these machines.

The exhibition included three English and one American coal-cutters. None of the systems combined, however, sufficiently satisfactory dispositions for their application in irregular and thin layers, which are most frequently met with, and require a very economical process of extraction.

While the best efforts in this direction have not yet been made, it is interesting to establish the fact that great progress has been made in their application.

First of all, a few words on the coal-drilling machines of M. Macdermott, London, England.

The different devices shown at the Exhibition are rather ingenious for facilitating hand-drilling, making the work more active and reducing the cost of manual labour. The auger is replaced by a gimlet of greater power; the slack passes through the screw without making the removal of the tool necessary. The advance of the tool is produced by means of an endless screw fitted with a crank at the opposite extremity from the tool, and passing through a nut attached to an iron stanchion, wedged in between the roof and the sides of the layer. The nut revolves on its bearings, and allows of directing the tool in all desirable positions.

The depth of the sounding may be increased by connecting iron rods between the gimlet and the endless screw, as is customary with the common sounding apparatus.

In the device which is recommended for drilling or sounding against the roof of the layer, the power is transmitted by pulleys connnected by chains, while another is adapted to the drilling of holes above and below the normal range of the workman's arm, in order to facilitate the work. The crank is connected to the nut at the end of the tool by means of a bevel-gang.

Mechanical English Coal-Cutter.

(*System of Gladhill.*) *Exhibited by* William Baird & Co., *of Coatbridge, Scotland.*

The machine acts on the coal by means of an endless chain, armed with teeth or blades, revolving around a shive or solid plate, secured over the coal. The machine is driven by compressed air, brought from the surface through pipes, under a pressure of 35 to 40 pounds to the square inch. The housing of the machine consists of a cast-iron frame 6 feet long and 3 feet wide, mounted on four wheels; on this frame are fixed two horizontal cylinders, converging towards a first vertical shaft, carrying the crank. A pinion is fastened on this shaft and revolves a wheel keyed on a second shaft parallel to the first, at the lower end of which a toothed wheel gears with the endless chain which revolves the cutters. The front part of the shive which carries the gearing around which the chain revolves, passes under the cast-iron frame supporting the engines. The shive with the chain receives a circular motion, directing it towards the coal which is to be separated; it is made in halves and secured together by screws. This device serves to keep the chain constantly tightened. The latter consists of flat links (English chain), each link being enlarged at one end for the purpose of holding the blades. The chain is made of cast-steel, and the cutters of good tool steel. The width of each cutter is $2\frac{1}{2}$ inches.

The machine advances automatically in proportion to the clearing of the coal, by means of capstans placed at both the forward and after ends of the frame, so as to work both ways. An ordinary chain is attached to a stanchion fixed in the mine close under the working surface; it revolves on the drum of the capstan, which latter is revolved very slowly and in proportion to the depth at which the knives are cutting into the coal. The rotary motion is produced on a ratchet-wheel of the drum by a connecting rod, receiving its to-and-fro motion through an eccentric keyed on the second vertical shaft of the motor. The machine runs on a rack twenty-one feet long, consisting of a series of rails, 3 feet long, connected by iron ties. The track is advanced by taking up and then placing forward the rails over which the machine has already passed.

The driving-cylinders are 6 inches in diameter, with a stroke of 9 inches. The face of the drum working the chain is 3 feet, the cutters therefore working the coal-bed to a depth of 3 feet, which may, however be increased. The width of the cut is $2\frac{1}{2}$ inches. The machine can advance and work in all directions; its height is 2 feet.

The inventors claim that it will advance 300 to 350 feet with a depth of 3 feet in 8 to 10 hours, producing 75 to 90 tons of coal, assuming the vein to be $2\frac{1}{2}$ feet thick. It requires two men and a boy to run the machine.

The movements of the mechanical coal separator are not adaptable to the undulations and irregularities met with in most coal mines. The apparatus would give entire satisfaction in a uniform layer, and good results would be obtained where it is only required to detach a regular coal-vein, which is free from slate beds or bony layers. The cut in the coal, which is the result of the cutting chain, is as slight as possible, and the waste of coal insignificant. This is in itself a good result; but, unfortunately, it must be taken into consideration that a bony or slaty bed is found in nearly all layers of coal, and that the necessity prevails to attack this before all other points, in order to separate the coal from its impurities.

The slate or bone beds are of irregular thickness and hardness; the mechanical separator would remove as much coal as bony matter if the layer be thin, or will only cut a notch in the mass if the trace be thicker. In either case, it would be necessary to complete the work of separating the slaty matter from the coal by hand with the aid of ordinary tools. This latter work would be facilitated, it is true, by previous mechanical work, but the time consumed and the difficulties met with in placing and moving the machine would necessarily prove a drawback.

English Coal-Cutter.

(*System of Holmes & Peyton, London.*)

Messrs. Holmes & Peyton exhibited a mechanical cutter in which a kind of saw, working by impact, is substituted for the dredge with knives.

The machine consists of a double platform of cast-iron, between the faces of which a vertical driving shaft transmits by cranks or gearing the motion to two shafts, and through these to shafts which, by means of eccentrics, communicate the motion to the toothed blade or cutting saw. A movable iron frame, carried on wheels, and running on rails, is intended to give a forward motion to the platform by means of a pinion, and a toothed rack fixed along the whole length of the frame. The cutting tool consists of a strong steel blade, which is attached to the two eccentrics in order to give it rigidity; the teeth are inserted in the plate and operate like picks, each tooth advancing on the same plane, and describing circles according to the impulse of the eccentrics. The length of the plate is 3 feet.

In starting the work the movable frame is brought on the track to the point of attack, the platform is turned by means of the crank of the pinion acting on the toothed collar which surrounds the platform, until it is nearly parallel to the face of the coal-vein. As soon as the rotary motion is given to the eccentrics and the pointed knife has advanced into the body of the coal at a right angle to the surface, the advance is made automatic by means of a lever, which throws the pinion into gearing with the toothed rack. The appa-

ratus exhibited is driven by four horizontal single-acting cylinders fastened on the top of the platform and working on the same crank. This driving machine presents a new and rather ingenious device. It is worked by steam, but may also be driven by water or compressed air.

This mechanical coal-cutter is lighter and of a more simple construction than the preceding one. It stands only $1\frac{1}{2}$ feet high, including the driving-machine. Its length is $2\frac{1}{2}$ feet, and the length of the movable frame is from 14 to 16 feet. This length may be reduced at will, but it would make it necessary to remove more frequently the tool, in order to bring it back again to the head of the toothed rack, the length of which is reduced with that of the frame.

The efficiency of Messrs. Holmes & Payton's coal-cutter has not as yet been demonstrated by practice, experiments having only been made by the inventors. The simplicity of its working parts and its peculiar mode of action distinguish it from others. The teeth of the cutting blade act by blows as the picks used in hand-labour. It is to a certain degree a "*rivelaine*"* with several teeth, worked mechanically, cranks being substituted for the hands of the workmen, where they would be applied to the handle of the tool; but the objection to the other machines holds good with this one, inasmuch as economical results can only be obtained in regular and thick layers, where the cutting is purely done in coal, without a slate bed. The machine can only be used to advantage under a solid roof, not needing any supports, which would materially interfere with its progress.

We will admit, with the inventors, that this machine is lighter and cheaper than all others previously invented, that it will cut quickly with less power and with as little waste as others; but, on the other hand, we must maintain that the clearance of the slack is not effected as completely as by machines provided with dredging-chains, and that the slack must often foul the tool.

The machine strikes 300 to 400 blows per minute, the opening of the cut is from $\frac{3}{4}$ of an inch to 1 inch to a depth of 3 feet. The inventors claim an advance of 8 to 12 inches per minute, according to the hardness of the rock or coal.

American Coal-Cutter.

Brown's Monitor Coal-Cutter.

This machine was exhibited by Messrs. Niblock, Zimmermann, & Alexander; it is now in use in the shafts of Coal Brook Mine, No. 3, near Brazil, Indiana, and is the only coal-cutter employed in the United States. It is constructed on the principle of the English Gladhill machine, exhibited by William Baird & Co. The work is also done by means of a dredging-chain. Some modifications have been made which improve the use, although they increase the weight, which is already too considerable.

The apparatus consists of a square iron frame, revolving upon a lower frame or bed-plate, upon which the driving and feed parts are arranged with the greatest economy of space consistent with freedom of movement and accessibility, and of a revolving cutter-rim, carrying the cutters and supported by a radial arm attached to the frame.

Its weight is about 1,500 kilos., its height from rail to top of rocker-valve chest is 3 feet, the extreme depth of cut is 56 inches. The air pressure required is 25 to 30 lbs. on the square inch. Coal-cutters built on this system have been in use since June 1873 in the mines owned by Niblock, Zimmermann, & Alexander. It is shown by a paper read by Mr. John T. Alexander before the American Institute of Mining Engineers,† that this machine has given satisfactory results. The coal, especially that of the lower vein, is very hard and dense, and wages rule higher in this field than in almost any other part of the United States.

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* *Rivelaine* is a peculiar kind of pick used in Belgian coal-mining. It has been used in Yorkshire for "nicking" or "bearing" coal. The action of this machine corresponds really to the swinging of a pick. It is not used in the United States.

† See *Trans. Am. Inst. Min. Eng.*, vol. iii., p. 23.

One of the most frequent objections advanced against coal-cutting machinery, viz., the rapid drilling of the cutting points, has been overcome in a satisfactory manner by the use of chrome steel. This steel has only lately been employed in the industries, and is characterised by its extreme hardness.

In the hardest coal yet met with 6 yards have been cut with one set of points, while in soft bituminous coal 25 yards have been reached. The points are sharpened from time to time on an emery wheel, and, if tempered with care, with last a long while.

Mr. Alexander claims the following advantages for this mechanical coal-cutter over hand-mining, on condition, however, that the cutting takes place in a vein, and considering that small coal is of little or no value in the United States :—

"The waste in the under-cutting process is reduced to such an extant that the saving is sufficient to pay the operating expenses of the machine. Experience in block-coal mining proves that one-sixth of the product is slack or waste; or, taking 100 tons as the basis of our calculation, 16 tons would represent this waste. The 1½ inch cut made by the machine is $\frac{1}{25}$ of a four-foot vein, the standard thickness in the block-coal region, and $\frac{1}{25}$ of the 100 tons equals, say 3 tons, which amount being deducted from the 16 tons, shows 13 tons of merchantable coal in lieu of the 16 tons of slack.

"The slack sells for $5 per car of 12 tons, or $6.66 for the 16 tons, while, on the other hand, the 13 tons of merchantable coal have a value of $2.25 per ton, or $29·33, a clear difference of $22.67 in favour of the machine from this one item alone. To operate the machine an engineer and two track-layers are required, at $3 for the former and $2.50 each for the latter per diem, making $8 for each shift producing 50 tons, or $16 for the two shifts producing the 100 tons, which deducted from the $22.67 still leaves $6.67 for oil, repairs, and expenses of the air-compressor, which is run by the engineer driving the hoisting-engine.

"The reduction of waste, therefore, in paying the cost of the under-cutting, leaves the taking down and loading of the coal as the only expense to be compared with the price of hand-mining. This being 50 cents. per ton against $1 as the average of hand-mining, puts the cost of 'getting' one half, and the dead work remaining the same as now, 50 cents per ton, the expense of putting coal on the cars at the mouth of the mine would not exceed two-thirds of the present cost.

"One man following the machine can take down and load 10 tons in a shift of 10 hours, so that very satisfactory wages could be earned at forty, or even thirty cents per ton for that work, which would still further widen the difference shown by the above calculation."

Coal-Mining Tools.

The Hardy Patent Pick Company, of Sheffield, England, exhibited a collection of mining tools, very commendable for their perfection of manufacture, and above all for the manner in which the tool is joined to the handle. The latter was fully illustrated by the different types exhibited; the attachment is effected either by pressure or by means of keys. The handles may readily be slipped on or off. They offer greater resistance than those generally employed, being stiffened with iron at the point subjected to the most severe strain. They may be left in the mine while the tools are taken up for repairs. The transportation of the implements requires less room and can be more readily accomplished after the handles have been detached. Great facilities are also offered in the heating and forging of the points, when this should be required, by taking off the handles. The price of these handles at Sheffield is 1*s.* 9*d.*; that of tools weighing 2 lbs., 1*s.* 9*d.*; tools of greater weight cost 6*d.* more.

Safety Lamps.

Cook & Co., of Birmingham, England, exhibited a collection of safety lamps employed in the mines of Great Britain comprising the systems of

Davy, Stephenson, and Dr. Clinney. The latter is generally provided with a glass cylinder, but a specimen was also displayed having a cylinder of mica. This substance offers greater resistance than glass to the influences of heat or cold, but is not sufficiently transparent to make a general change desirable. All these lamps were manufactured with great care.

The firm of Cosset-Dubrulle, of Lille, France, also exhibited a full collection of lamps used for mining purposes in their country, comprising samples of fifteen different styles, but showing no novel features. The exhibit formed a full collection of all lamps employed by miners, from the simple Cosset with unprotected flame to the most elegant safety lamp with crystal cylinder and rich copper mountings.

The productions of this house are highly commendable for the great care taken in their manufacture, and also for their low prices.

Safety-Fuses for the Ignition of Gunpowder used in Exploding Mines.

Safety-fuses were only exhibited by the firms of Davey, Bickford, Watson, & Co., of Rouen, France, and Muller & Co., of Clermont, near Liege, Belgium.

The similar productions of these houses are equally entitled to commendation for the great care taken in their manufacture.

There were no extracting machines, draining machines, ventilating machines, or accessory machines displayed at the Exhibition, except a model on a small scale of "The American Coal-breaker," exhibited by Coxe Brothers & Co., of Jeddo, Pennsylvania. This is a coal-separator, specially designed for the requirements of the American anthracite coal market. The model exhibited presents the most complete type of any apparatus of the kind.

The American section contained some machines for washing coal, but none of them offer the economical advantages indispensable for this kind of work.

GEOLOGICAL AND MINERALOGICAL COLLECTIONS AT THE EXHIBITION.

By James M. Safford.

The nations, colonies, states, and territories making geological and mineralogical exhibits, in which we include rocks, fossils, minerals, ores, models, maps, sections, and reports were not far from one hundred in number. The United States was represented by collections of greater or less extent from forty states and territories. Other nations contributing were—

The Dominion of Canada, including the provinces of Ontario, Quebec, New Brunswick, Nova Scotia, and British Columbia; Greenland (Denmark); Mexico; Bermudas, Bahamas, Jamaica, and Trinidad (British); Cuba (Spanish).

Venezuela; Peru; Chili; Brazil and the Argentine Republic.

Great Britain, including England, Wales, Scotland, and Ireland.

Portugal; Spain; France; Belgium; Netherlands; Denmark, including Iceland and the Faroe Islands; Germany; Sweden, Norway; Russia; Austria; Switzerland; Italy; Turkey.

Egypt; Tunis; Canary Islands (Spanish); Liberia; Gold Coast (British); Orange Free State; Cape of Good Hope.

British India; Ceylon and Straits Settlements (British); China; Japan; Siberia (Russian); Java and Madura (Netherlands Colonies); Philippine Islands.

The Australian colonies, viz., New South Wales, South Australia, Victoria, Queensland, and Tasmania.

New Zealand (British); Hawaii.

In addition to the countries mentioned and formally exhibiting, other parts of the globe were represented by specimens in some of the general collections.

From this enumeration it is seen that the Exhibition, in the feature under consideration, was, as in many other respects, a world's display. Nearly all the nations had ores and minerals, many rocks and fossils, not a few maps, models, and sections. The immediately practical or technological character of the exhibits was everywhere apparent. Thus, the ores of the common metals, stone-coal, building stones, marbles, grinding and abrading materials, clays, &c. were present in profusion, while collections of fossils and systematic series of rocks and minerals, for strictly scientific purposes, were not so numerous, and, with notable exceptions, not extraordinary.

The United States.

As a whole, the geological and mineralogical display made by the United States, though not complete, was as full and varied as could have been expected; it was indeed grand, and worthy of the Republic. No patriotic intelligent American could visit the Centennial grounds and come away without feeling a just pride in his country, in its vast mineral resources, and in the knowledge, energy, and skill of his countrymen as there manifested in the treatment and application of these resources to useful purposes. Nor did the showing suffer by comparison with contributions of the same class from other nations. Indeed, such comparisons but enhanced his original appreciation of our mines, minerals, and economic rock-material.

The Smithsonian Collection.

This was a large, rich, and instructive collection, made by the Smithsonian Institution. It occupied the north-eastern portion of the Government Building, and was in charge of Prof. W. P. Blake. The objects of this display were for the purpose of illustrating: "1st. The nature and variety of "the mineral resources of the United States. 2nd. The geographical distri- "bution and geological associations of the minerals. 3rd. The extent to "which they have been utilised. 4th. The mechanical, metallurgical, and "chemical processes by which they are extracted or converted into useful "products. 5th. The inherent and comparative qualities of the extractive "products.—A portion of the collection was arranged according to the nature "of the objects, irrespective of locality, but the bulk of the exhibition was "grouped geographically by States. There was also a section devoted to "models and drawings, and one to geological maps and graphic charts." As presented, this Smithsonian display included a large number of individual collections, aggregating a multitude of specimens. A majority of the States and Territories were represented, and in the notices of them to follow frequent reference will be made to the collection. The models, graphic maps, &c. brought together as a part of this display illustrated most satisfactorily and instructively the geology of portions of the Western Territories.

Alabama.

The exhibits from this State consisted principally of iron ores and bituminous coals. Iron ores, limonite, fossiliferous red ore abound in the northern part of Alabama. The most considerable display was in one of the annexes to the Main Building. It was made by the South and North Railroad, and was the work of Professor William Gesner, of Birmingham, Alabama. It included—

"1st. A geological cabinet section in miniature of the Warrior coal-measures, representing 46 seams of coal of all dimensions from one inch up to six and a half feet thick, aggregating 96 feet, of which 14, being two feet and over, are considered workable. Also beds of black-band iron ore, fire-clay, sandstone, and carbonate iron ore, or clay ironstone.

"2nd. A geological section in miniature of the Cahaba coal-measures, representing 51 seams of coal from one inch up to six feet in thickness, aggregating 81 feet, 16 of which being two feet and over are considered workable. Also beds of clay, ironstone, fire-clay, building sandstone, and flagging.

"3rd. Specimens of red hematite iron ore, existing in large deposits upon the line of road, in some places indicating a thickness of 28 feet, and of pig iron made therefrom at the works of the Eureka Iron Company. These works comprise two blast-furnaces, with a capacity each of 10,000 tons per annum. The coals, ores, and limestone used are owned by the company, and are in close proximity to the furnaces."

The Woodstock Iron Company made an elegant display of limonite. There were a few other exhibits of coal and iron ore. A geological map of Alabama was exhibited in the Smithsonian section.

Arizona.

This distant South-western Territory was represented by a good collection of its ores. There were ores of copper, silver, and lead, together with gold, gold quartz, and other minerals. The collection was made through ex-Governor R. C. McCormick, and formed a part of the Smithsonian contribution. Arizona silver ores were also exhibited in collections from San Francisco.

Arkansas.

The mineral and geological products of this State were on exhibition in the Arkansas Building. The display and enterprise manifested were commendable. Semi-bituminous coals, lead, zinc, and iron ores made a prominent part of the collection, but the most characteristic were the specimens of novaculite and the large crystals of quartz from the region of the famous Hot Springs. Both novaculite and crystals were remarkable. The former is a very fine-grained, white, silicious rock, highly valued as an oilstone and well known in commerce. It is sufficiently described elsewhere. There were two full and very interesting exhibits of the manufactured stones in the Main Building. In the Arkansas Building were large pieces of the crude rock. The quartz crystals were isolated, and in great groups of extreme beauty. A full description of both the novaculite and crystals may be found in D. D. Owen's *Second Geological Report on Arkansas*, 1860. Among the minerals were beautiful specimens of wavelite and crystals of brookite; also large and curious pieces of silicified wood; sulphide of antimony, galena, and tetrahedrite.

California.

Had the Legislature of California provided the means this State, so noted for its mineral wealth, and so interesting in its general features, would have supplied the Exhibition with a geological museum worthy of the great occasion. The State had a building, but it was erected through the praiseworthy efforts of private individuals. The exhibits, as to minerals, rocks, and geological maps, were not such as we had hoped to see. Eight collections, containing gold and silver ores and gold "cements," received awards. These, made by individuals from different parts of the State, were interesting and valuable. The San Jacinto Tin Manufacturing Company presented an interesting series of tin ores and block tin. In addition there were five exhibits of quicksilver and cinnabar, one including crude sulphur. These exhibits were in charge of the Smithsonian Institution.

Kansas and Colorado.

These States were fortunate in having a large, attractive building well-filled with minerals and products of the forest and farm. The contents were taste-

fully arranged, and the place was a popular resort. The building contained collections illustrating the geology and palæontology of the two States. Colorado made an extraordinary exhibit of large, argentiferous galenas, or silver-lead ores. The Pelican Mine, of Clear Creek County, contributed a specimen weighing 4,500 pounds, showing the vein formation, and said to contain $800 worth of silver; the Dives Mine, of the same county, a specimen weighing 3,140 pounds; and the Baxter Mine, ores weighing 3,000 pounds. There were three other exhibits of the same ores, two from the county mentioned and one from Boulder County. Gilpin County supplied very large masses of gold-bearing iron and copper pyrites; of these there were four exhibits from as many mines, one mass weighing 1,000 pounds. Of silver ores there were four exhibits receiving awards. One mass from Park County was large enough to show the vein formation, and weighed 3,500 pounds. In addition, there were collections of gold, gold ores, gravel, and cement; also, a display of coal and building-stone. Some of the silver-gold ores were tellurides.

Connecticut.

Granites of gray and red colours and superior texture, brown sandstones from Portland, and verd-antique marble from Milford, received awards. There were four exhibits of the first, two of the second, and one of the third. To the Smithsonian illustrative collection Connecticut contributed, in addition to the above, barite, feldspar, and silica for pottery purposes, kaolin, clays, limonite, and spathic iron ores, and a geological map of the State.

Delaware.

Delaware was represented by a State collection of minerals and rocks illustrative of its economic geology, including ores of iron and chrome, together with feldspar, mica, serpentine, and granite. There were also private collections showing the ores mentioned, building-stones, kaolin, and clays.

Georgia.

The Selma, Rome, and Dalton Railroad supplied a series of bituminous coals, iron and copper ores, roofing-slates, marbles, and fire-clays, from this State. The series included the ores and pig-irons of eight furnaces. Other furnace companies displayed ores and the materials used in the manufacture of iron. The gold resources of the State were represented by an exhibit of gold, auriferous gravel, and gold-bearing quartz in the Smithsonian collection.

Idaho and Montana.

These Northwestern Territories contributed in a number of private collections, which were exhibited in the Smithsonian cases, numerous specimens of gold and silver ores. Eight collections from Idaho and five from Montana received awards. The specimens came from many different mines, and consisted of native gold, gold ores, silver ores, gold-bearing argentiferous galena, and silver-gold ores. T. H. Kleinschmidt, of Helena, Montana, made an interesting exhibit of curious forms of native gold and gold crystals, containing one hundred specimens.

Illinois.

The Illinois Industrial University of Natural History, Champaign, Illinois, supplied a large and instructive exhibit of lead ores, among which were many large cubes of galena. There was also a collection of lead ores from Jo Daviess County. Besides the lead ores there were no other geological or mineralogical exhibits.

Indiana.

This State enriched the Exhibition with very full and satisfactory displays of its geological resources. Most of the collections were under the charge of E. T. Cox, State Geologist. Economic mineral and rock-material from this State were seen in the Main Building and in one of its annexes, in the Smithsonian collection, and disposed in front of the Indiana Building. Bituminous coals, building-stones, iron ores, and clays were most prominent. In addition were peat, grindstone and oilstone rocks, hydraulic limestones, marble, sand for making glass, and soils. In front of the building were large masses of coal weighing from one to three tons each. The display of coal comprised all the varieties found in the State, caking, block, and cannel. With these were building-stones (oolitic limestones and sandstones), some specimens containing over one hundred cubic feet. In the Main Building and Annex were heaps of the white porcelain clay known as indianite, from Lawrence County. This clay is remarkable for its freedom from iron, its plasticity and infusibility. It is considered one of the best materials for the manufacture of white ware.

Iowa.

Bituminous coals, peats, building-materials, hydraulic limestones, clays, gypsum, and lead ore are the geological products yielded by Iowa. The State received commendation for a collection illustrating its geology and mineralogy, and also for its bituminous coals, as illustrated by the exhibits of Westerly Redhead and the Mahaska Coal-Mining Company. An award was granted to J. R. Harvey for a large and instructive series of the galenas of the State. See further, page 486.

Kentucky.

In one of the annexes to the Main Building the Geological Survey of Kentucky, N. S. Shaler, Director, had a very handsome, well-arranged, and full display, illustrating the geology and mineral resources of the State. It was under the supervision of J. R. Proctor, Assistant Geologist, and included rocks, fossils, ores and coals. Specimens of the soils and the underlying rocks were arranged in instructive sections. Many detailed chemical analyses were given, as well as carefully-executed geological sections, and a preliminary geological map of the State, embraced in a very satisfactory *General Account of the Commonwealth of Kentucky*, a work of 100 pages, prepared expressly for the Exhibition. Most prominent among the geological resources of Kentucky are stone-coal, iron ore, and building-stone. Very many furnaces exhibited ores and the materials used in the manufacture of iron. The building-stones were well represented, among which the oolitic limestone, quarried at Bowling Green, is to be noted. There were also specimens of the well-known hydraulic limestone of Louisville and vicinity, lithographic stones, marbles, clays, salt-brines, and petroleum. The fossils in the collection, coal-plants, corals, crinoids, and shells, showed that the palæontological feature of the Survey had not been neglected. The display was highly creditable to the State and to the gentlemen who did the work.

Louisiana.

In the Smithsonian exhibit were specimens of rock-salt from the remarkable bed of this material lying beneath the "Orange Sand" formation of Petite Anse, or Avery's Island, on the coast of Louisiana. With these were also specimens of sulphur from the same State.

Maine.

The most important exhibits made by Maine were specimens of granite and roofing-slate. The first were of pleasing colours, sound, and susceptible of

good polish; the latter were commended for strength and general good quality. In addition to these were iron ores, feldspar, quartz, and sand for pottery purposes. A gealogical map of the State, by C. H. Hitchcock, was included in the Smithsonian collection.

Maryland.

The geology and mineralogy of this State was illustrated by a large and well-arranged collection of specimens. E. Mortimer Bye, of Wilmington, made a display of the verd-antique marble of Maryland, which was commended for its magnitude and variety, and for the good texture and colour of the material. There were also exhibits of iron ores, fluxes, and stone-coal.

Massachusetts.

In the Smithsonian exhibit was a varied and interesting series of the minerals, ores, and economic rock-material of this State, together with metallurgical products and a geological map of its territory. Iron ores, siderite and magnetite, emery and corundum, corundophilite, diaspore, rutile and ilmenite, argentiferous lead ore, copper ores, granites, syenites, and porphyries, with sets of the latter beautifully polished, sand for glass-making, kaolin, clays, alum clays, limestone, and marble, were included in the display. An award was granted to J. T. Ames, of Chicopee, Massachusetts, for an instructive group of samples of the Chester emery with the accompanying rocks and minerals. Massachusetts granite from Quincy and Cape Ann was displayed in several pieces of wrought work upon the grounds. Awards were also given for brown sandstone, and sand for glass, remarkable for its purity. In the collection of geological maps made and exhibited by Professor C. H. Hitchcock, one of this State was included.

Michigan.

The magnificent specimens of native copper and hematite from the northern part of Michigan, placed in one of the annexes of the Main Building, were the wonder of all who saw them. There were four large blocks of native copper, each a cubic yard or more in volume, cut from a mass weighing seventy-six ton, at Central Mine, in Keweenaw County. Another mass, from Isle Royale, weighed 5,720 pounds. Accompanying these were piles of copper-bearing rocks, great masses of "copper conglomerate," crystals of copper, and collections of native silver, and copper with silver. Near by was a huge mass of nearly pure hematite, weighing fifteen tons, from Marquette County. For a list of mines contributing to the display from the Lake Superior district, see *Report on Awards*, Group I., No. 438. The State was further represented by specimens of sandstones for building purposes, and grindstones, marbles, and slates, magnetites, bituminous and cannel coal, clays, and sand for glass, mineral waters, brines, gypsum, and marls. There was a series from this State in the Smithsonian section. Among the awards was one to E. Gaujot, of Michigan, for a new and detailed geological map of the Upper Peninsula.

Minnesota.

Granite of this State, of red, white, and blue colours, was exhibited by H. D. Gurney, of St. Paul. It was commended for variety and good quality.

Missouri.

The mineral and economic rock-material of Missouri were well represented in the Exhibition by carefully-arranged series of minerals, rocks, and fossils. These exhibits received high commendation. The lead and iron ores of the State, and their geological relations, are remarkable. See further, page 487.

Nevada.

Minerals and ores from this State were arranged in the Smithsonian collection. Conspicuous among them were numerous specimens of silver ores, argentiferous galenas, rich exhibits of molybdate of lead (wulfenite) from the Lucin district and the Eureka Consolidated Mine, and masses of native sulphur from Humboldt County. Among the silver ores were samples of ruby-silver from Yankee Blade and Morey districts and from the Belmont Mine, and a large specimen of the telluride of silver from the Prussian South Mine. There were large and valuable exhibits of horn-silver, stephanite, and silver-glance ores from the Consolidated Virginia Mines of Storey County; horn-silver from the Philadelphia district; gold ores from the Pine Grove district; copper ores from Battle Mountain; crude borax, borate of lime, and rock-salt from Esmeralda County; crystals of saltpetre, rock-salt, and crude soda from Churchill county; arragonite from the Lucin district. The State was commended for a very complete exhibit of its mineral resources, and for the "Nevada Quartz-Mill" erected upon the grounds for the purpose of showing, by actual work, the process of manipulating the ores of the precious metals. Thirty distinct awards were made to individuals and mining companies for collections of native silver and silver ores from this State. Most of the collections contained silver-lead ores, often gold-bearing. They represented numerous mines and districts.

New Hampshire.

The large exhibit of this State, consisting of minerals, granites, metamorphosed and other rocks, with maps, was mostly arranged in the collective Smithsonian series. The Exhibition was greatly indebted to Prof. C. H. Hitchcock, State Geologist, for the collection, and the map intended to illustrate the work of the Geological Survey. Wrought work of New Hampshire granite was shown in several exhibits upon the grounds.

New Jersey.

Great praise was awarded to New Jersey for the very complete and systematic exhibit made by its Geological Survey, George H. Cook, Director. The exhibit embraced (1) specimens of all the rocks of the various formations known in the State, including the potter's-clay and greensand; (2) the ores of iron and zinc and the products of their metallurgical treatment; (3) the building-stones; (4) a fine collection of the rare crystalline minerals of the region; (5) plans illustrating the mode of occurrence of the magnetic iron ores, a model of the Sterling Zinc Mine, and the geological maps published by the State Survey, all giving a very full and most instructive view of the scientific and economic geology of the State. In keeping with the whole, a tasteful and most satisfactory catalogue of the exhibit had been prepared and printed. Prominent in the collection were the magnetic iron and zinc ores. The magnetites of the State lie in the Azoic (Archæan) formations, occurring in beds interposed conformably between layers of the gneiss rocks. The mines now opened in these ores number nearly 200, and are capable of supplying 1,000,000 tons of ore annually. The ores are rich, and meet with ready sale. The zinc ores, the oxide, silicate, and franklinite being the principal ores, were represented by many specimens, some very large, from Stirling Hill and Mine Hill, in Sussex County. In the collection were hematite from Marble Mountain, limonite and siderite from numerous localities, ores of copper from several counties, galena from Sussex, and arsenical iron from Warren. The suites of rocks included granites, syenites, gneisses, limestones, dolomites, marbles, sandstones, slates, trap-rocks, as well as clays, marls, greensand marls and sands.

The restored skeleton of the *Hadrosaurus Foulkii*, a gigantic extinct lizard, the bones of which were found in the green marl of Haddonfield, New Jersey, was one of the wonderful objects in the Main Building. It was restored and erected by Professor B. Waterhouse Hawkins. For a sketch of the formations of New Jersey, see page 488.

New York.

Economic geological products from this State were on exhibition in the Smithsonian collection. Displays of magnetic iron ores, hematite, red, purple, and green roofing-slates, bluestone flagging, and black marble received awards. There were, furthermore, displays of galena, graphite, kaolin, clays, and mineral waters. Reference may be made here to the attractive and valuable series of palæontological models exhibited in the Main Building by Professor H. A. Ward, of Rochester, New York. The models or casts, especially of the large extinct animals, are admirably adapted for scientific instruction.

North Carolina.

The Geological Survey of this State, W. C. Kerr, Director, made an exhibit of the building and ornamental stones, including granites, marbles, and limestones. There were also other exhibits, the whole presenting a fine series of the minerals of North Carolina, among which was an interesting collection of corundum and the associated minerals, of gold, silver, and copper ores, iron ores, including magnetite, steatite, and mica. To these was added a geological map of the State.

Ohio.

This State made a remarkable display of its building-stones, coal, and iron ores. A large number of the exhibits of building-stones, which were sandstones and limestones, but principally blocks of the celebrated sandstones of Ohio, were used in the construction of the Ohio State Building. A list of the stones thus used is given in the *Reports on Awards*, Group I., No. 108. In addition there was a large number of other exhibits of building-rocks; also, interesting displays of grindstones. The exhibits of coal were very numerous. See *Reports on Awards*, Nos. 87 and 95, Numerous iron-furnaces exhibited specimens of the ores used by them, among which were clay iron-stones and black-band ores found in Ohio. Besides there were grooved and striated rocks from Kelley's Island, flagging-stones, clays, sand for glass and pottery, and salt from the brines of Pomeroy and the Hocking Valley. The geological maps and reports of the State Survey were also on exhibition.

Oregon.

From this State there was an exhibit of gold ores of interest and value from the Virtue Mine, made by J. H. Jackson, of Baker City.

Pennsylvania.

The Exhibition owed much of its interest and wealth of display to the geological and mineralogical contributions of Pennsylvania. The Second Geological Survey, J. P. Lesley, Director, presented an attractive series of rock, mineral, and organic remains of the State, with admirable local maps, sections, and models in relief. Details of this exhibit are given in the Supplement, see pages 490–492. There were also individual displays of bituminous, semi-anthracite, and anthracite coals (*Reports on Awards*, Group I., Nos. 92, 93, and 94), black marble from Lycoming County, nickel and cobalt ores from Lancaster, and zinc ores from Bethlehem.

Rhode Island.

The Providence Franklin Society, of Providence, received commendation for an exhibit of the ores and minerals of this State. The collection included fossil plants from anthracite. In the Smithsonian space were granite for building and ornamental purposes, magnetite, anthracite, and graphitic coal, some specimens being in large masses.

South Carolina.

From this State were exceedingly interesting and suggestive displays of mineral phosphates. These are partly nodular in character, and are associated with fossil teeth, vertebræ, and other bones. They come from beds which rest upon the Eocene in the vicinity of Charleston and other portions of the coast region, and are extensively used for fertilising purposes. The Smithsonian collection contained a suite of minerals and ores illustrating the native resources of the State.

Tennessee.

The leading native resources of a geological and mineral character in Tennessee are iron ore, bituminous coal, copper ore, marbles, and building-material. Others having more or less commercial interest are gold, zinc ore, lead, manganese oxides, barite, petroleum, clays, millstone-grits, roofing-slates, hydraulic and lithographic limestones, brines, and mineral waters. Most of these were well represented by collections located in the Main Building and in the space occupied by the Smithsonian display in the United States Building. These were supplemented by a geological map of the State, and by a large map showing the mineral resources of the district around Chattanooga. The iron ores of Tennessee, in the order of their importance, are limonite, hematite, magnetite, and clay ironstones, the latter of which have never been used. There are four distinct areas or belts in the State in which beds of iron ore occur, as follows;

1. The Eastern Iron Belt—Extends through the State, and lies chiefly in front and at the base of the Unaka Range of mountains. It reaches beyond the limits of the State, to the north-east into Virginia, and to the south-east into Georgia. The most important ore is limonite, which is found in deposits in the great masses of débris resulting from the solution and disintegration of pyritiferous limestones, dolomites, and calcareous shales. Veins and beds of hematite and magnetite occur in the northern counties of this belt. The magnetite in Carter County lies but a few miles from great beds of a similar ore in North Carolina.

2. The Dyestone Belt—Skirts the eastern base of the Cumberland table land, or of Walden's Ridge, from Virginia to Georgia; spreads out laterally from ten to twenty miles into the Valley of East Tennessee; the Sequatchie and Elk Valleys are included. This belt reaches for to the north-east beyond the limits of the State, and to the south-west into Georgia and Alabama.

Red fossiliferous ore occurring in stratified beds, one to four in number, and from an inch to three feet and sometimes more in thickness, is the characteristic product.

3. The Cumberland Table Land.—Co-extensive with the coal-measures of the State, and extending into Kentucky and Alabama. The ores in this are inferior, being clay ironstones, and black bands that have never been used for the making of iron in this State.

4. The Western Iron Belt.—This is the largest area, and lies west of Nashville and mainly between the latter and the Tennessee River, though extending a few miles in some counties west of the river. Northward it reaches into Kentucky. Its ores are nearly all limonites.

Copper ore is confined to the Ducktown mines in the south-eastern corner of the State. Variegated marble, of which there were full displays both of the rough and the wrought, is quarried at a number of points in East Tennessee. The rock is practically inexhaustible.

The coal formation of Tennessee caps the Cumberland table-land and has an area of 5,100 square miles. It will average (not including the north-eastern portion) from 500 to 600 feet in thickness. In the north-eastern portion, and within the counties of Morgan, Anderson, Scott, Campbell, and Claiborne, there are high ridges, towering above the general level of the table-land, in which the coal measures have a thickness of more than 2,700 feet, and include not less than sixteen beds of coal. One of these, near the base of the mountain, is extensively mined, and is from 4 to 7 feet thick. Other

beds occur, not yet explored, but showing outcrops of 3 and 4 feet. In all the counties, wholly or in part on the table-land, outcrops of coal are found, many of which are of workable thickness.

Utah.

Like Nevada, this Territory had very many specimens of silver and silver-lead ores on exhibition. Big Cottonwood, Little Cottonwood, and Ophir districts, Bingham Cañon, and Parley Park mining district were represented. Some of the exhibits were collections, each embracing specimens from many mining districts. W. T. Barbee, of Leeds, Utah, exhibited a curious and rare specimen of horn-silver, occurring in sandstone, in which were fossil dicotyledonous plants. This was from the Tecumseh Mine, Harrisburg mining district. Two large specimens of argentiferous galena from the Hidden Treasure Mine, and silver ores from Tintic, were among the exhibits.

Vermont.

Specimens of marble, granite, steatite, and copper ores from this State received suitable acknowledgments. The marbles, wrought and unwrought, were interesting. One block of statuary marble, six feet long, of pure colour and homogeneous texture, from West Rutland, attracted especial attention. Other exhibits included statuary marble from Rutland and West Rutland, coloured marbles from Swanton, Rutland, and Burlington, and marble from Pittsford. There were granite monuments and tablets from St. Johnsbury commended for the work and material, and granite exhibited by a company of Thomaston of superior character. In the Smithsonian collection the native resources of Vermont were illustrated by series containing marbles, slates of various colours, roofing-slates, iron and copper ores, kaolin, sand for glass-making, and scythe-stones.

Virginia.

This State has varied geological and mineralogical resources. Its mines of lead, salt, and gypsum, in the southern portion, are remarkable; its mineral waters are justly celebrated and widely known. Coal and iron ore abound. Four collections received awards, as follows: A series of the ores of Virginia; a collection of clouded marbles; roofing-stones; and a display of superior iron ores. The Smithsonian authorities exhibited from this State zinc and lead ores, including calamine, galena, and cerussite; iron ores, limonite, hematite, fossil ore, and magnetite; copper ores; gold-bearing quartz; manganese oxides; gypsum; barite; brines and salt; coal; granite; and kaolin.

West Virginia.

The West Virginia display was highly satisfactory. The State had a building in which were arranged a multitude of specimens illustrating its natural resources of all kinds: an extensive series of woods; agricultural products; pupils work; maps; works of art, &c. Prominent among these were the mineral resources, coal, iron ores, building-stones, hydraulic limestones, marble, clayss, mineral waters, salt-brines, petroleums. The exhibits of coal were very numerous, as might have been anticipated, since this State contains within its limits 16,000 square miles of coal-measures, nearly 28 per cent. of the entire area of the Appalachian Coal-field. Out of fifty-four counties, only six are without coal-beds. The kinds of coal on exhibition were bituminous, semi-bituminous, splint, block, and cannel. Among the iron ores there were numerous specimens of carbonates and black bands, the analyses of many of which were given; limonites in variety, and fossiliferous ores; hematite, many with analyses. There were also white sands for glass-making; white flint; black flint from a stratum six feet thick; yellow ochre; barite; fire-clays with analyses, and some without a trace of iron; whet-

stones; Ritchie mineral, or grahamite, from Ritchie County, the mine now exhausted. A neat catalogue of the exhibit was circulated. Forty-two counties of the State contributed. A work on the *Resources of West Virginia*, of 430 pages, by M. F. Maury, was prepared under the direction of the State Board of Centennial Managers, and copies were presented to visitors.

Wisconsin.

The Exhibition was indebted to Wisconsin for a good display of crystalline rocks and a fine series of organic remains from the palæozoic strata of the State. In addition, there were good exhibits of the Clinton red iron ores, found at Mayville; Huronian magnetites from Penokie Range; bog and other iron ores; galenas; a variety of copper ores; zinc ores; kaolins; peat; sands; mineral paints; a variety of granites and other building rocks, and porphyries. The different formations were systematically illustrated by suites of rocks and fossils, and their economic contents and products by suitable specimens. The formations of Wisconsin are the *Laurentian*, occupying one-third of the area of the State, though often buried beneath the drift; the *Huronian*, mostly confined to the Penokie Range in Ashland County and the Menomonie iron district in Oconto County; *Potsdam Sandstone*, occupying a large area; *Lower Magnesian Limestone; St. Peter's Sandstone; Trenton Limestone*, consisting of two limestones,—the *Buff*, eight to twenty feet thick, and and the *Blue*, one hundred feet thick; *Galena Limestone;* the *Cincinnatti Group*, the topmost of the *Lower Silurian*; *Cinton; Niagara*, including the *Racine Limestone*, at the top of the *Upper Silurian;* Hamilton, of *Devonian* age; and lastly, the Quarternary.

The State had at hand a book of 85 pages bearing the title, *The State of Wisconsin; embracing Brief Sketches of its History, Position, Resources, and Industries, and a Catalogue of the Exhibits at the Centennial at Philadelphia*, 1876.

Dominion of Canada.

The section of the Main Building assigned to Canada was a national museum in itself. Crowded with specimens, well arranged and in great variety, it was the admiration of visitors. The collection was an aggregate of displays, including, with that of the Geological Survey, which was by far the most important, and the nucleus about which the others were gathered, a multitude of displays from Ontario, Quebec, Nova Scotia, New Brunswick, and British Columbia. No one could see the collection without being impressed with the greatness and varied character of the mineral wealth of Canada. The Geological Survey, Alfred R. C. Selwyn, Director, received commendation for the great merit of its collection, which included the economic minerals of the Dominion, together with specimens of the economic rock-materials, an interesting series showing the various rock formations, a fine and complete group illustrating the history of *Eozoon Canadense*, and the published maps of the Survey.

The following entry, made by the Survey, in the Official Catalogue of the Exhibition, and taken as typical of the entire collection in the section, will convey an idea of the richness and varied character of the Canadian exhibit:

a. Quartz, magnetic sand, and alluvial gold, models of gold nuggets, platinum, copper pyrites, native copper, magnetite, magnetic iron sand, hematite, iron ores, iron pyrites, native iron, antimony, ore, galena, blende, barite, mica, magnesite, kermesite, celestite, albite, orthoclase, asbestos, amethyst, agates, and Canadian rocks.

b. Coal from Saskatchewan River, bituminous shale, crude, and inspissated petroleum.

c. Sandstones, marbles, marble column, dolomite, limestone, syenite, granite, gneiss, labradorite, jasper, conglomerate, ornamental, and polished slate, cut and polished stones.

d. Hydraulic cement, gypsum.
e. Clay, fire-clay, clay for moulding, river and moulding sand, soapstone.
f. Graphite.
g. Lithographic stones, grindstones, whetstones, buhrstones, granite for millstones.
h. Brine, mineral water, phosphate of lime, shell marl.

Many of the specimens were of large size, and not a few remarkable for their beauty.

Greenland (Denmark).

Cryolite, of which there were massive specimens in the Exhibition, represented Greenland. It was exhibited as a crude material from which the salts of sodium and aluminium, together with other products, are manufactured. Cryolite is shipped from West Greenland in large quantities. It occurs in a remarkable bed or vein in gneiss.

We add also the large mass of the wonderful meteorite from Ovifak, displayed upon the grounds near the Main Building.

Mexico.

About 400 specimens of minerals, rocks, and ores were on exhibition from this country, some of which were noted for size and interest. They were comprised in numerous minor collections, and included principally ores of silver, mercury, lead and iron, silver-lead, crude sulphur from the volcano Popocatepetl, and marbles. A large exhibit of bromide of silver (bromyrite) from Catorce, State of San Luis Potosi; an immense mass or cake of silver, cupelled from two hundred and seventy-two tons of lead, and weighing four thousand and two pounds, from the reduction-works of Trojes, State of Michoacan; a specimen of meteoric iron of large size from the State of Chihuahua, weighing four thousand pounds; and a large block of a peculiar and beautiful stalagmitic limestone from Puebla bearing the name of "Mexican onyx," used as an ornamental marble, were attractive objects in the display, the cake of silver and the onyx, with the articles made of it, especially arresting public attention. See further, page 492.

Bermudas, Bahamas, Jamaica, and Trinidad (British).

Among the many curious and useful objects from these islands a few were illustrative of their geology and mineralogy. From the Bermudas were fragments of a stalagmite and a stalactite, taken from beneath the surface of low water in a partially-submerged cave. These were exhibited in evidence of the subsidence which has thrown the floors of nearly all the caves below low-water mark. These islands, and also the Bahamas, contributed assortments of building-stones. The Bahamas and Jamaica made exhibits of salt, much of which is exported. Commendation was bestowed for an exhibit of asphalt, taken from the Pitch lake of Trinidad. It included the crude mineral, boiled asphalt, and glance asphalt, the latter similar to bitumed, indiacum, and commercially known as Greek pitch.

Cuba.

In the Spanish section were large and instructive displays of asphalts from the island of Cuba. They were commended for the quality of the material and for general interest.

Venezuela.

The Exhibition contained from this country a superior and full suite of specimens of free gold ores and amalgams from various mines in Venezuela. There was also a case filled with ores, coal, and geological specimens intended

to illustrate the resources of the country. This display was made in the Agricultural Hall.

Peru.

To this Government an award was justly granted for a well-arranged collection of its ores, rocks, and native minerals, supplemented by numerous analyses. "The collection consisted of 250 specimens, which were held in "place by wire attachments, and included ores of zinc, galena, molybdenum, "antimony, and arsenious acid, realgar, a variety of copper ores, also of silver, "argentiferous galena, iron ores, carbonate of copper and silver, malachite, "azurite, sandstone, and cinnabar from Huancavelica; also a variety of "asphalts and coal, nitrate of soda in native blocks, and a variety of "marbles."—*G. C. Broadhead.*

Chili.

"The Chilian collection was fine, in portions rare and beautiful. The national collection included 300 specimens of silver ores; also the blue arragonite from Caracoles. Edward Sene exhibited 400 specimens, including copper, silver, &c., and also fossils from the Cordilleras. The collection of Emilio Escobar deserves particular mention, and included 445 specimens, chiefly of silver ores, among which were fine blood-red crystals of ruby-silver (proustite), chlorides, chloro-bromides, sulphurets, native silver, and horn silver, with gold. The Catalogue names proustite, chilenite, silver, and chalcosite, cerargyrite, embolite, iodyrite, argentite, galenite, chalcopyrite, gold, and cinnabar."—*G. C. Broadhead.*

Brazil.

"The mineral and geological collection of Brazil was varied, and included typical specimens of nearly all the rocks, ores, and minerals, as well as precious stones of the empire. The display of tourmalines was most interesting. The crystals were numerous, and of various shades of colour; red, violet, green, and black. There were topazes, some in quartz and mica schist; diamonds, one of them large; also amethyst of fine quality; large, clear pebbles of rock-crystal; a hollow chalcedonic pebble, containing transparent liquid; also beryl, pyrite, smoky quartz, itacoulumite, sulphur, aquamarine, rutile, sheets of mica, kaolin, magnetic iron, goethite, and a variety of other iron ores, stalactites; specimens of gold. The coal, bituminous shales, and marble were represented in variety. The various rocks were illustrated by nearly 200 specimens."—*G. C. Broadhead.*

For a notice of the geology and mineralogy of Brazil, see page 493.

Argentine Republic.

The exhibit from this country was an aggregate of many private and provincial collections, with that of the University of Cordova. The specimens, generally small, were at least 1,200 in number. Ores of silver were very numerous, most of the collections containing them. There were also ores of lead, copper, manganese, antimony, nickel, cobalt, iron, chromium, gold, with other minerals, such as gypsum, sulphur, salt, crystals of quartz, barite, copperas, alum, calcite, feldspar, mica, talc, lapis-lazuli, glauber salt, tourmalines, garnets, beryls, lignites, coals, marls, clays, kaolin, asbestos, bituminous schists, ochres, nitre, marbles, whetstones, lithographic and hydraulic rocks, serpentine, porphyries, granite, slates, volcanic stones, and other minerals and rocks which it is not necessary to enumerate. The whole was wonderful for its variety. Many of the specimens, or suites of specimens, were intended to illustrate some special feature of a metallic lode or some geological relation, and in the catalogue prepared by the Republic instructive notes on many specimens were freely introduced. The palæontological display was meagre, though a number of the collections contained fossils.

Great Britain.

The geological and mineralogical displays of crude material from Great Britain were by no means proportionate, in extent and interest, to the displays made by this country in other departments of the Exhibition. One part, however, of the geological exhibit received the highest praise,—a selection of the superb maps and sections of the Geological Survey of the United Kingdom. This embraced geological maps of parts of England, Wales, Scotland, and Ireland on the scale of one inch to one mile; maps illustrative of the coal-fields of parts of Northumberland, Durham, Lancashire, and Yorkshire on a scale of six inches to one mile; horizontal sections, six inches to the mile, descriptive of the geology of the country over which they are drawn, giving the outline of the ground and the dip of the beds; and vertical sections 40 feet to the inch, giving details illustrative of the maps and horizontal sections. These were supplemented by ten volumes of memoirs descriptive of the maps, thirteen volumes devoted to British organic remains, and mineral statistics for five years, commencing with 1870, the whole showing the vast and thorough work done by the Survey. England exhibited iron ores, cannel and gas coals, and materials for the manufacture of concrete and Portland cements. The Gray's Chalk Quarries Company presented a display of chalk and chalk flints, with articles prepared from chalk. G. K. Harrison displayed crude Stourbridge fire-clay, and specimens of the same clay arranged to show the very small amount of contraction the pieces suffer in being subjected to intense heat. Robert Dunn & Co. showed pieces of "China clay," with samples for potting, bleaching, paper manufacturing, and other purposes. Wales was represented by admirable roofing-slates; Scotland and Ireland by beautiful red and gray granites, mostly wrought into polished monuments.

Portugal.

Ores of copper, antimony, lead, zinc, tin, manganese, and iron; numerous and excellent building-stones in many exhibits; specimens of marble, in variety and great number; slates, anthracite, apatite, whetstones, hydraulic cement, and mineral waters, were the minerals and economic materials in the geological display of Portugal. From the mine of S. Domingos, in Mertola, Province of Alemtejo, were very large and notable masses of iron-pyrite, containing an average of 2·75 per cent. of copper, with maps and drawings illustrating the general features of this interesting and anciently-worked locality. An ingot of silver and a small lump of gold, extracted from 500 tons of the ore, were exhibited more as matters of scientific interest than for any commercial significance attached to them. Other mines were illustrated by good maps. Recent geological maps of the kingdom, and parts of the kingdom, merited and received attention for their scientific interest.

Spain.

The mineral and economic rocks of Spain were well represented by a host of specimens, from many provinces and in great variety, well displayed, many of them of good size, all instructive and highly suggestive of varied and great native wealth. From the Horcajo Mine were mining maps and a good industrial and mineralogical collection. The corps of Mining Engineers, Madrid, presented a collection, consisting of pieces of ore from all the principal mining districts of the country, together with statistics. The varieties of marble in polished blocks were numerous. With these were slabs of granite and green serpentine. The rock-salt of Cardona was represented by a full collection of beautiful specimens. Among the ores were cinnabars from Almaden and other points, iron ores from many provinces, galenas, ores of manganese, nickel, cobalt, tin, silver, zinc, and copper.

There were also specimens of barite, gypsum, and alabaster, sulphur, asphaltic rock, and lime phosphates, the latter from several mines worked by the Fraternidad Society; displays of stalactites, jasper, stone coals, graphite,

jet, steatite, building stones, grindstones, whetstones, tripoli, slates, clays, and mineral waters.

The section of the Main Building assigned to Spain contained also exhibits from the Canary Islands, the island of Cuba, and the Philippine Islands. Notices of these exhibits are given under the head of Canary Islands and of the two colonies respectively.

France.

Prominent among the French displays were crude masses, as well as dressed blocks and many manufactured millstones, of the well-known and unexcelled buhrstones from the tertiary deposits of La Ferté-sous-Jouarre (Seine-et-Marne). The best varieties of the buhrstone were to be seen in the commendable exhibits made. These were located in the Agricultural Hall. Near them was a display of lithographic stone, in fine slabs, some of large size, the material dark-bluish or dove-coloured, and of good quality, the collection of the Lithographic Stone Quarry Company, of Paris. Other articles in the building were cement materials, with manufactured products, lime phosphates, chalk, marble, and moulding sand. In the Main Building Eloffe & Co., Paris, presented a good systematic suite of rocks and minerals, about 500 in number, arranged for purposes of instruction. Geological maps of France were entered by the Department of Public Works, Paris.

Belgium.

An award was granted to the Bleyberg-ès-Montzen Joint Stock Company, Province of Liége, for a full aud instructive series of lead, silver-lead, and zinc ores, raw and mechanically prepared, with their metallurgical products. Buhrstone, much like that of the Paris basin, from quarries in Ermeton and Temploux, Belgium, was well displayed in the millstones exhibited in Machinery Hall, by L. Dassonville de St. Hubert, of Namur. Basècles (Hainaut) contributed samples of black marble for pavements, and stones of blue and gray colours. To this county also the Exhibition was indebted for copies of the classic palæontological works of Dr. L. De Koninck, of Liége, and of the works on mining by C. De Cuyper and A. Noblet.

Netherlands.

The geological and mineralogical portion of the display made by the Netherlands was limited. It consisted principally of clays from the mother country, and small collections of ores, minerals, and rocks from the East Indian colonies, the whole inadequately representative of the kingdom and its dependencies.

Germany.

The minerals, economic rock-material, and geological maps contributed by the German Empire constituted, taken together, one of the most interesting and prominent displays of its class in the Exhibition. The collections comprising the display were divided between the Main Building and Machinery Hall. In the first was a magnificent and costly collection of pieces of amber in their native state, which attracted great attention. With it was a case of selected specimens, each enclosing a fossil insect in its transparent mass. The amber represented a great industry, there being nearly 3,000 workmen engaged on the coast of the Baltic in obtaining it. Near by, and representing seven manufacturing establishments, was a joint exhibition of the rock-salt and potash-salts of the wonderful beds of Stassfurt, with illustrative maps. In the same section were also slabs of the renowned lithographic stones of Solenhofen, and an array of superior geological maps of Prussia, Thuringia, and Bavaria. In Machinery Hall the famous manganiferous spathic iron ores of Siegerland were well displayed in attractive heaps and pyramids, in connexion with their metallurgical products, especially

spiegeleisen. Other ores of iron and specimens of coal were shown. In the same building were millstones and stones for polishing and abrading wood for paper pulp. To these were added a joint exhibition (representing many works, great capital, and thousands of hands) of lead, copper, zinc, lead-silver, and copper-silver ores, and the products of their reduction. There were also asphaltic rocks and clays; and, not to be overlooked, an admirable set of glass models of crystalline forms for purposes of instruction.

Denmark (including Iceland and the Faroe Islands).

Denmark was represented in private collections, mainly ethnological, by a few minerals from Iceland, Faroe Islands, and Greenland. See also under Greenland, page 475.

Sweden.

The Swedish contribution was very creditable. It consisted prominently of iron ores and the products of their reduction, copper ores, wrought porphyry, polished granites, marbles, and other rocks, grindstone and millstone grits, cement materials, and geological maps. The Jernkontoret, a Swedish association of ironmasters, made a collective exhibit of iron ores (magnetites and hematites) and their products, in which nineteen iron works were represented. The exhibit was commended, both as a scientific and instructive one, showing not only the raw materials, but the means employed for their treatment. Forming a part of this collection were maps of mines and a general map of the principal mining districts in Sweden, with a suite of minerals illustrating the map. Other exhibits of iron ores were made by companies and individuals. Ores of nickel, zinc, and lead, as well as specimens of coal and peat, were also presented. The Geological Survey of Sweden exhibited admirable maps, with good illustrative collections of rocks and fossils.

Norway.

The collections in the Exhibition from Norway were, like those from Sweden, very satisfactory. Thanks are due to several gentlemen of the Geological Survey of Norway, Dr. Th. Kierulf, Director for many excellent maps, sections, and generalized representations, and series of rocks and minerals elucidating the geology and mineralogy of this country. A number of nickel and copper mines contributed suites of ores, with products and slags, showing what has been done in the production of these metals. The nickel mines are very promising, and some recently discovered employed, in 1870, two hundred men, and produced ores and nickel to an amount of $100,000. The Kongsberg Silver Mines had an atttractive display of native silver and silver bars, with the associated minerals of the lodes, including sulphides of silver, calcite, quartz, barite, fluorite, &c., also a plaster cast of a large nugget found in 1867, and weighing 161 kilogrammes. The annual production of these mines is now about 4,000 kilogrammes of silver and 10,000 kilogrammes of copper. Titanic iron ores, stones for pavements and curbs, slates for table-tops, floors, and roofs, specimens of apatite and millstone, were also among the Norwegian contributions.

Russia.

The part of the Main Building occupied by Russia was a centre of great attraction, both for scientists and the public, made so chiefly by magnificent displays of rich and rare minerals and a remarkable collection (that of Hoessrich & Woerffel, St. Petersburg), of costly and beautiful vases, urns, tables, table-tops, mantels, and other articles of ornament wrought out of malachite, lapis-lazuli, rhodonite and labradorite, the stones coming mostly from the Ural Mountains and Siberia. The principal exhibit of minerals was contributed by the Imperial Mining School, and embraced 343 choice specimens from the Urals, Siberia, and Finland, some of them of great value.

Among them were specimens of gold, silver, platinum, and copper, also ores of antimony, tin, zinc, lead, mercury, and iron; telluric silver, chromic and titanic iron; topazes of extraordinary size and interesting crystalline forms, emeralds, aquamarines, garnets, zircons, tourmalines, jaspers, agates, lapis-lazuli, malachite, and many other species. This school exhibited furthermore a collection of rocks and fossils illustrative of formations in the empire. The Department of Mines, St. Petersburg, was highly commended for a display of native platinum, some masses of great size, osmiridium, purified platinum, and specimens illustrating its various stages of production. Other exhibits included ores of iron, copper, zinc, gold, and gold-bearing earth, coals, clays, graphite, plaster, and mineral waters; also a series of maps and sections of great scientific interest, illustrating the geology of the Ural Mountains and other parts of Russia.

The Austro-Hungarian Empire.

Though ranking in varied mineral wealth among the richest countries of Europe, this empire had comparitively a limited display of rocks and minerals. Nevertheless there was much of interest in the exhibitions made. From the Duchy of Carinthia was a commendable and instructive series of geological specimens and ores; from Bohemia and the Tyrol a collection of the fine garnets, rough and cut, for which localities in these dependencies are so famous; from Hungary, a group of beautiful and valuable rough opals, one of which, a slab weighing 602 carats and rich in equisite colours, was valued at twenty-five thousand dollars; from Bukowina, specimens of the manganese oxide (pyrolusite) so extensively mined in this duchy, 5,750,000 kilogrammes being yearly raised and used in Austria and Germany by the makers of aniline colours, glass, and soda; from Galicia, asphalt and mineral resin and the ozocerite or "mineral wax" used for making candles. Other collections included ruddle and red chalk, and a variety of celebrated mineral waters.

Switzerland.

The geology of the great tunnel of the St. Gothard Railroad was illustrated by geological tables and sections, as well as by a pyramid of rock specimens, which was surrounded by a group of quartz-crystals. Swiss asphaltic rock, commended for the superior quality of the asphalt, was exhibited by the Neuchâtel Asphalt Company. There were furthermore ten volumes on the geology of Switzerland, with numerous geological maps, the exhibit of the Swiss Geological Commission.

Italy.

This country favoured the Exhibition with samples and collections of native sulphur, rock salt, volcanic and miscellaneous minerals, marbles and alabasters in variety, limestones, earthy pigments, slabs of banded quartzites (flagstones), lithographic stones, and mineral waters. The displays of sulphur, raw and refined, were numerous. In Agricultural Hall was a full display of the dove-coloured lithographic stones of the Oneglia quarries. Many stones, neatly trimmed, some of large size, were included. In this building also were seen duplicate sets of the interesting Vesuvian minerals, the property of Giovanni Cozzolino. Among the Italian minerals was a collection of crystallized specimens for which Francesco Tagliavia & Co. received an award.

Turkey.

Emery, an important mineral product of Asiatic Turkey,—which country, together with certain Grecian islands, is the great source of commercial supply,—was represented in the Turkish section by several cabinet specimens from a number of localities in the Province of Aydin and other provinces. Other exhibits from Turkey included specimens of meerschaum (sepiolite),

talc, chalk, lignite, coal, graphite, sulphur; lead, silver, and silver-lead-ores; chromic iron and copper ores; rock-crystals, marbles, clays, and mineral waters.

Egypt.

The National Museum of Egypt entered for exhibition specimens of gold-dust, marbles rough and wrought, alabaster, lime and plaster, clays, and materials for pottery, petrified wood, sand, and soils.

Tunis.

Among the exhibits of His Highness the Bey of Tunis was a collection of minerals and ores illustrative of the native resources of this country. The chief mineral products of Tunis are ores of lead and mercury, saltpetre, and sea salt.

The Canary Islands (Spanish).

A display of building-rock from these islands, the material of volcanic origin, received favourable notice for their representative character. Specimens of jasper and flagstones were also entered.

Liberia.

This republic had an interesting miscellaneous display, illustrating its resources and products, in Agricultural Hall, embraced in which were numerous specimens of iron ore.

Gold Coast (British).

Gold Coast is the name generally given to the portion of Upper Guinea, West Africa, which stretches along the Gulf of Guinea from the river Assini on the west to the river Volta on the east. Specimens of gold-dust and numerous ornaments made from the gold of the country, a block of granite polished by native workmen, and pieces of white clay used in medicine and to "chalk" divorced wives, were entered among the curious objects in the exhibit from this region.

Orange Free State.

In the attractive collection contributed by this South African state were a number of geological and mineralogical specimens. A collection of uncut diamonds was remarkable and attracted general notice. One of these was imbedded in its native matrix. Another of good size was a well-formed crystal of modified octahedral form. A lot of pebbles, samples of those which accompany the diamonds, specimens of copper and iron ores, chlorastrolite, magnesite, stone-coal, and kaolin were also exhibited.

Cape of Good Hope.

This colony was represented, in the way of minerals, by commendable displays. An award was granted to H. C. R. Bright for a satisfactory series of minerals, among which were iron, copper, and tin ores. Collections of diamonds with the associated rocks were highly appreciated. These were supplemented by displays of galena, copper ores, black oxide of manganese, saltpetre, and coal from the Stormbergen and other South African coals. There was further a geological map of Cape Colony.

South African Republic.

W. A. B. Cameron of this republic was commended for "a rich collection of gold nuggets from Pilgrims' Rest Creek, near Delagoa Bay, east coast

of Africa. This is a large and rich collection, being valued at fourteen thousand dollars, and mined by the exhibitor by the process known as sluicing. With the gold is a small collection of various minerals indigenous to that country, including a beautiful specimen of amber in which is imbedded a tsetse fly. The entire collection is of great scientific interest, the nuggets running from one hundred to fourteen hundred dollars each in value."

British India, Ceylon, and the Straits Settlements.

Through the agency of the Director of the Indian Museum, London, the Exhibition was supplied with a large and rich series of minerals, stones, and mining products, carefully classified, and gathered from different parts of India, the island of Ceylon, and the Straits Settlements, illustrating the varied mineral resources of this part of Asia. The selections made from the Museum consisted of magnetites, hematites, limonites, and magnetic iron sands from several of the Presidencies; chromic iron ores, manganese oxides; copper pyrites from the hills of Beloochistan, and malachite from Central India; galenas from numerous districts; antimony ores; tin-stone from Ceylon, Malacca, and five other districts; gold sand, arsenical ores, sulphur; coal from five districts, including Malacca; lignite; petroleum and naphtha from Burmah; rock-salt from salt ranges; saltpetre, limestones, "laterite," calcite, selenite, micas, agalmatolite, zeolites; a variety of clays—fire, china, and ball clays—from many districts; quartz, ochres, earths, graphites, from five districts, including Ceylon; corundum from Madras, Salem, and Mysore; agates and carnelians from Cambay; gem sand from Ceylon; ruby sand, rough garnets; calderite from Nepaul; tourmalines, fibrous gypsum, and epidote granite.

Specimens of graphites, raw and refined, from Ceylon, and in a different exhibit, received commendation for their superior character and purity.

China.

In the truly grand and characteristic display made by the Chinese Empire, crude geological and mineralogical material occupied a limited space. The Imperial Maritime Customs entered specimens of coal, granite, borax, and gypsum. Articles made of jade were exhibited, one of which, a jade-stone tablet, was valued at $500. Borax from Thibet was among the articles selected for exhibition out of the Indian Museum.

Japan.

Japan had, like China, a magnificent series of wares, products, and manifold curious objects. The rocks and minerals of the country were moderately well represented. Coal, iron ore, and porcelain clays constitute the most important part of the mineral wealth of Japan, and these had their representative specimens in the Exhibition. The Japanese Mining Department exhibited a good collection of the ores of iron, copper, lead, and tin; also specimens of coals, including anthracite, the display showing, in addition to mineralogical features, the condition of metallurgical industry in the country. A separate mineral and geological collection, from the island of Hokkaido, was also entered. Great interest was taken in a Government exhibit, by the Kuwangiyo-Riyo (Imperial Board of Agriculture, &c.), of "clay, china-stone, kaolin, silex, and other materials used in the manufacture of the pottery and porcelain of Hizen, Owari, and Ise." The Imperial Commission, Tokio, displayed a well-arranged suite of Japanese building-stones, which was highly commended for "its magnitude, symmetry, and representative character, and for the care and good taste with which it had been prepared." Other exhibits included petroleums, limestones and lime, and mineral waters. A cut globe of rock-crystal, six inches in diameter, and valued at fifteen hundred dollars, was a brilliant and attractive ornament in the Japanese section.

Siberia (Russian).

Siberian minerals and rocks, some of exquisite beauty and great value, all highly interesting, enriched the Russian collections. (See Russia.)

Philippine Islands (Spanish).

Ores of iron, lead, and gold, with samples of coal, well selected, and in some cases accompanied with analyses, together with a metallurgical collection embracing iron and copper, were contributions from these islands of South-eastern Asia.

Australia.

Notwithstanding the fact that Australia is nearly antipodal to the eastern part of the Union, as distant as it well can be, the different provinces of this vast island, with its adjunct, Tasmania, held a very conspicuous place among the nations in the great Exhibition. A profusion of crude and wrought material, ores, rocks, fossils, wares, goods, products of the mines, the waters, the forests, the fields and the shops, maps, catalogues, books, models, "trophies," &c., attractively displayed or freely distributed, arrested attention and advertised, in no feeble manner, the remarkable resources of this new part of the earth, and the wonderful progress that Anglo-Saxons have made within a few years in its metamorphosis from a savage to a civilized and enlightened condition. Numberless persons learned for the first time what Australia is and what it promises. We notice briefly the mineralogical and geological displays of the different colonies and provinces.

New South Wales.

This, with Victoria, forms the south-eastern part of Australia, the latter lying south of the former. New South Wales did a great part in giving interest and importance to the mineral and geological features of the Exhibition. The contribution made was especially remarkable for its magnificent array of tin ores, in a score of collections, consisting in the aggregate of many hundred specimens of tin-stone (cassiterite) in different forms, such as stream-tin, pebbles, black sand, lode tin, and crystals, of which there was a very full and beautiful series.

A great display of gold, gold nuggets, auriferous quartz, gold in quartz and slate, &c., was also made, supplemented by a gilded "trophy," representing the volume of gold obtained in New South Wales from 1851 to 1874, the value of the gold being 30,536,246*l.* 10*s.* 6*d.* Copper and iron ores in great variety, blocks of coal and sections of coal-beds, marbles, building-stones, precious stones, kerosene shales, and cabinets of fossils, were prominent.

The Department of Mines, Sydney, exhibited a collection of ores and other minerals, rocks, and fossils, numbering more than 700 specimens, and embracing, in addition to the kind of ores, &c., spoken of above, ores of mercury, antimony, lead, cobalt, arsenic, and antimony; chromic iron, titaniferous iron, wolframite; specimens of asbestos, quartz-crystals, fluorite, epidote, calcite, tourmaline, talc; schists, granites, serpentine, obsidian, and petrified woods. Of precious stones, the collection contained diamonds, opals, sapphires, carnelians, jaspers, and zircons. The fossils were numerous, and arranged to illustrate the principal sedimentary formations of New South Wales. Among them were bones of species of *diprotodon* and other marsupials. Included in other exhibits were numberless specimens of tin-stone, and, with minerals already mentioned, topazes, garnets, chalcedonies, idocrase, molybdenite, pyromorphite, magnesite, and also kaolins and clays.

New South Wales is to be commended for a well-digested catalogue of its exhibits, and for various instructive works and maps relating to its mineralogy and geology, copies of which were on exhibition.

South Australia.

The province thus designated comprises nearly one-third of the entire area of Australia. It ought to be called Middle Australia, as it forms a belt, extending north and south, and from sea to sea, across the middle of the Island Continent. The settled and improved portions are on and near the southern coast, the more northern portions being yet in a wild condition. The great mineral product of South Australia is copper ore. The province contains some of the most famous and richest mines of the world, as the Burra-Burra, the Wallaroo, and the Moonta. These mines, with others, among them the North Yelta, the Doora, and the Balhannah, had rich displays of copper ores and copper, which were justly commended for fullness and for the variety of specimens and the purity of the metal extracted. R. S. Crabb, of Adelaide, contributed a beautiful block of malachite from the Burra-Burra, together with attractive pieces of azurite. Next to copper ores in importance rank the iron ores. These are abundant and were duly represented.

The South Australian Commissioners illustrated the gold resources of the northern territory by collections of auriferous quartz from many localities. Bismuth from the Balhannah Mine, marbles, sandstones, and slates from quarries near Adelaide, and coorongite, a remarkable substance, found on the surface in tough, thin cakes, and resembling india-rubber, hence called "mineral caoutchouc," were also exhibited.

South Australia yields, in addition to the products noticed, ores of antimony, cobalt, nickel, mercury, platinum, silver-lead, precious stones, and many other minerals. The province prepared for the Exhibition a large volume, with maps and illustrations, edited by William Harcus, Esq., J.P., on its history, resources, and productions, a work of great interest and one of the best of the kind contributed.

Victoria.

This colony, though much the smallest, is by far the most populous province of Australia. It made a good showing of rocks and minerals in the Exhibition, the aggregate of the collections numbering more than one thousand specimens. There were granites, syenites, porphyries, felsites, diorites, basalts, schists, quartzites, breccias, sandstones, slates, limestones, shales, coals and lignite, rocks illustrative of the different formations; gold and gold ores, bismuth and bismuth-gold, osmium-iridium, silver ores (embolite); nickel, tin, copper, lead, zinc, antimony, manganese, iron, and chrome ores; rock-crystals, precious stones, and a variety of other minerals; kaolins, building-stones and marbles, lithographic and sharpening stones, and fossil fruits.

One collection of specimens of auriferous quartz contained one hundred and twenty-nine pieces, each of which was noticed in the Official Catalogue of Victoria. A group of gilded fac-similes of the great gold nuggets found in the diggings of the colony since 1858 excited the curiosity of all. There were twenty-five of these, the originals having rejoiced in such names as the "Beauty," the "Platypus," the "Kum Tow," the "Needful," the "Welcome," &c. The Acadia Catherine Mine exhibited valuable specimens of gold ores. Gold is by far the most important mineral product of Victoria. The amount raised in 1874 was valued at 4,630,000*l*.

A cabinet of gems and precious stones, the exhibit of the Rev. J. I. Bleasdale, of Melbourne, contained diamonds, blue and green sapphires, rubies, aquamarines, topazes, spinels, beryls, opals, garnets, tourmalines, &c., found in the colony. The antimony ores and regulus, as well as a block of nickel ore, were worthy of special mention. The general display was made the more complete by a satisfactory Official Catalogue, and by the contribution of R. Brough Smyth, of Melbourne, consisting of a geological map of Victoria, various local maps and reports on the geology, palæontology, and mines of the colony.

Queensland.

The section of the Main Building assigned to Queensland was well filled with a diversity of exhibits systematically arranged, the mineral, geological, and metallurgical portions making a very prominent part of the whole. The north side of the rectangular section was devoted to the illustration of the geology and mineralogy of the colony, by means of sets of photographs illustrating the several formations, and by specimens of the rocks, soils, fossils, and mineral products pertaining to them, disposed in table-cases. Each of the formations had its set of photographs and its table-case, the latter under the former, and, on the wall above both, a "tablet of information." On the same side, towards the east, was suspended a large coloured map of Queensland. Facing the geological map, on the opposite and south wall of the section, was an instructive mining map, showing the position of the various gold, copper, and other mining districts. Occupying the east end of the area of the section, and between the two maps mentioned, were exhibits of ores and metals in bulk.

The Government of Queensland had a collective exhibit, in which were included a valuable series of specimens of auriferous quartz and gold nuggets from the Gympie, Cloncurry, Ravenswood, Rockhampton, and Palmer diggings, and a gilt obelisk representing the production of gold during eight years. Gold is the most important mineral product, and occurs at numerous points over the colony. In 1874 the yield of gold was about 1,000,000*l.*, which was greatly increased the succeeding year.

Copper ores (including a splendid slab of malachite) and ingots, tin ores and tin, with ingot trophies of both metals, called attention to these as elements in the mineral wealth of Queensland. Copper ores are mined at many points; tin ores near the borders of New South Wales, in the Stanthorpe district.

Other exhibits were ores of antimony, mercury, bismuth, manganese, and iron; samples of stone-coal, building-stones, polished serpentine, chalcedony, agate, and graphite; and a remarkable collection of precious opals, numbering one hundred specimens, many of great beauty and value, from the Valley of the Barcoo, in Western Queensland.

Tasmania.

Tasmania, like its neighbouring colonies, made a good representation of native products. Among the contributions were commendable exhibits of tin ores, principally from the rich and noted deposits of Mount Bischoff, also from George's Bay and Ringarooma; gold in quartz from the City of Hobart Mine; limonite, hematites, and magnetites, with the iron produced, from several localities; bismuth from a promising lode in the rocks of Mount Ramsey; roofing and school slates, from Piper's River, on the north-east coast; coal from Harefield and the river Don; specimens of petrified wood, marbles, fossiliferous limestones, gray and brown sandstones, topazes, and beryls from Bass's Straits Island, asbestos, and clays.

Tin takes the lead in importance. The Mount Bischoff Tin Mining Company exhibited a ton of tin ingots. The total production of this metal in 1874 was 490 tons, valued at 38,220*l.*, while that of gold was valued at 18,491*l.* The same year a quarter of a million of slates were prepared for sale from the quarries of Piper's River.

A map of Tasmania, showing the gold, coal, iron, and tin deposits, and a volume of statistics, were also contributed.

New Zealand (British).

The colony of New Zealand, consisting of three principal islands, the North, the Middle, and the South (or Stewart's), added interest to the Exhibition by many exhibits of the classes we are considering. There were numerous specimens of alluvial gold, gold nuggets, auriferous quartz, &c., from many localities. This metal has been produced largely in New Zealand, principally in the North and South Islands. Rich gold fields were discovered in the spring of 1857. The total yield of gold up to the 30th of September 1875 was 7,875,676 ounces, valued at 30,672,834*l.*

The coal resources of the colony are remarkable. Blocks of bituminous coal, respectively from seams three, eight, and sixteen feet in thickness, were exhibited; also blocks of anthracite and brown coal, and specimens of petroleum. Other minerals were iron ores, limonite, hematite, and magnetite; chrome, lead, silver-lead, zinc, copper, antimony, and manganese ores; graphite, steatite, varieties of amphibole, and carnelian. Among the rocks were marbles, limestones, trachytes, obsidians, and clays of several kinds. Supplementing these were maps showing localities of mineral deposits.

Hawaii.

Finally, from the middle of the Pacific, and representing the Hawaiian kingdom of volcanic islands, were interesting geological specimens, including lavas and minerals from the famous volcano of Kilauea, together with maps and views of this and other volcanoes and their craters.

SUPPLEMENT TO THE GENERAL NOTICE OF THE GEOLOGICAL AND MINERALOGICAL COLLECTIONS.

I. IOWA AND ILLINOIS.

By G. C. Broadhead.

The following is a list of the formations found in Iowa and Illinois, arranged in their proper sequence, and with their respective thicknesses stated in feet.

Formation.	Iowa.	Illinois.
Cretaceous	280 feet.	
Upper Coal	200 „	1,400 feet.
Middle Coal	200 „	
Lower Coal	200 „	
Chester	—	500 to 800 „
St. Louis	75 „	200 „
Keokuk	90 „	150 „
Burlington	190 „	200 „
Kinderhook	175 „	150 „
Black Slate	—	10 to 60 „
Hamilton	200 „	120 „
Oriskany	—	40 to 60 „
Clear Creek Limestone	—	350 „
Niagara	350 „	50 to 200 „
Cincinnati	80 „	60 to 140 „
Galena	250 „	275 „
Trenton	200 „	50 „
St. Peter's	80 „	150 „
Calciferous	250 „	100 „
Potsdam	300 „	0 „
Huronian	500 „	0 „
Laurentian	0 „	0 „

The State of Iowa had twelve illustrative sections exhibiting the character of the several geological formations of the State. The sections were represented by specimens of the various sandstones, limestones, coal, and galena placed in their appropriate stratigraphical relations. With the rocks were also intercalated the chief fossils of the formations. The thickness of each formation was also placed opposite the name.

The coal-measures are similar to those of Missouri, and underlie nearly one-half of the State. The upper measures include only one workable seam in the western portion of the State; the middle measures include 6 seams of coal, 4 of which are workable; the lower measures contains the thickest seams.

The Galena limestone, according to Professor White, occupies a narrow strip of country, seldom exceeding 12 miles in width, but is 150 miles long

north and south, and is 250 feet thick at Dubuque, diminishing in thickness and width north-west. The Dubuque lead district extends across into the neighbouring States of Illinois and Wisconsin.

The Iowa lead region proper is confined to Dubuque County. Both galena and carbonate of lead are found, the ore occurring chiefly in east and west lodes, although some is also found in north and south lodes. Lead was found in this vicinity in the year 1700, but it was not until 1798 that much mining was done. In that year Julien Dubuque, an Italian trader, obtained a grant from the Sacs and Foxes of a large tract of land on the west side of the river, where he soon engaged in mining. Still, mining was not regularly commenced until about 1822. Since then it has regularly progressed.

There are two lead districts in Illinois, one in the north-west part of the State, the other in the southern part, in Hardin County. The Upper Mississippi lead region, according to Whitney, occupies an area of 4,000 square miles in Illinois, Iowa, and Wisconsin, of which two-thirds lie in Wisconsin. The other third is equally divided between Illinois and Iowa. According to Whitney, the most productive portion of this region lies between Dubuque and Galena and Shullsburg, so that both Iowa and Illinois raise more lead in proportion to their area than Wisconsin. The lead district of Illinois lies chiefly within Jo Daviess and Stephenson Counties. Professor Whitney gives 275 feet as the thickness of the Galena limestone, and states that a circle of four miles around Galena will include nearly all the productive lead region.

In Hardin County, lead is mined in the subcarboniferous limestone of the age of the St. Louis group, and according to Dr. Norwood's report the galena is found in lodes and associated with fluor-spar, and occasionally some blende. The mines have been worked 100 feet in depth.

Professor Worthen estimates the coal formation to cover more than two-thirds the State's area, or 35,000 square miles, and to include in their northern extension 5 to 6 workable seams, with an aggregate of 20 feet of coal. In the southern part of the State it is estimated that there are 1,200 feet of measures, and a total aggregate in the State of 1,400 feet, extending from the base of the lower to the upper inclusive. In this are included 16 workable seams, 6 or 7 of them in the upper measures, the whole aggregating 35 to 40 feet of coal, several of which occasionally thicken as much as 5 to 7 or 9 feet. The thickest seams are mined in the southern part of the State, and the quality of the coal is good, being much used in iron foundries.

The coal measures of Illinois do not materially differ in their character from the Missouri measures, but probably include a larger proportion of sandstones and shales.

II. MISSOURI.

By G. C. Broadhead.

There were on exhibition about 1,000 specimens of minerals and rocks, including ores, minerals, rocks, clays, and fossils. Among the rocks were specimens of building-stones, including granite from Iron County, Madison, and François; porphyry from Iron and Reynolds; marble from St. François and Iron; polished specimens of Trenton limestone from St. Louis County; Lower Carboniferous limestone from Knox County; hydraulic limestone from St. Louis; potter's clay from Iron, Jefferson, and Pettis; kaolin from Iron County; and fire-clay from St. Louis and Vernon Counties.

The geological formations were not fully represented, but there was a small but good collection of fossils from the Lower and Upper Carboniferous systems, presented by Dr. John H. Britts, of Clinton, Missouri. Only a few specimens of bituminous and cannel coal were exhibited. The iron ores in their several varieties were well represented, and included specimens from seventeen counties, among which were specular ore, both granular and micaceous; soft and hard red hematite; compact, fibrous, and stalactitic limonite, pyrite, and magnetite and bog ore, and manganiferous iron.

There were manganese ores from Iron and Reynolds Counties. Iron ores were exhibited from Iron, Madison, St. François, Reynolds, Dent, Phelps,

Franklin, Pulaski, Henry, Cedar, Vernon, Johnson, and Linn Counties. Mr. Edwin Harrison, of Iron Mountain County, had on exhibition a piece of ore weighing several tons. There were good ochres from Iron, Dent, Vernon, Johnson, and Linn Counties. St. Geneviève, St. François, Madison, Phelps, and Shannon Counties furnished copper ores, including chalcopyrite, azurite, and malachite. Lead ore is mined in twenty-nine counties in Missouri, but only twenty of them furnished specimens for exhibition. The best exhibits of lead were from Madison, Washington, Franklin, Jefferson, Webster, Christian, Newton, Jasper, Morgan, Cole, and Miller Counties. Mr. J. R. Gage had a specimen from Miller County that would weigh nearly 1,000 lbs., and Mr. Parsons, of St. Jo. Mines, one of 1,500 lbs.

Zinc ores occur at most of the Missouri lead mines, and often in paying quantity. At Mine La Motte, Madison County, galena occurs with nickel, cobalt, and copper. Cerussite is also found at Mine La Motte. At St. Jo. Mines, in Washington County, the galena is well crystallised, and many large masses, when broken, show crystals of cerussite. Anglesite and pyromorphite are also sometimes found. At some of the Palmer mines the galena breaks with an exceedingly smooth surface, and some specimens from these mines are entirely coated with calamine.

From Mammoth Mines, Jefferson County, were specimens of galena nicely crystallised in cavities which were lined with pyrites, and also blende on quartz and pyrites. Some of the galena from Old Mines, Washington County, is well crystallised in cubes. From J. R. Patton's mines, in Christian County, were large-sized cubes of galena. The galena at Old Jones Mine, in Morgan County, occurs with a gangue of barytes in a vertical lode, varying from a few inches to thirteen inches in width. At Cole Camp, Benton County, there is a similar lode, in which galena, blende, pyrites, and barytes occur. The overlying clay here contains small and nicely-shaped galena cubes adhering to masses of barytes.

Much of the galena from Boaz Mines, Cole County, is coated with transparent cerussite, and compact cerussite has been mined here in large quantities.

At Granby, Missouri, the galena is sometimes well crystallised, and in it are found blende, calamine, buratite, cerussite, smithsonite, and calcite.

At Joplin have been obtained the handsomest crystals of galena, both in form of small and large cubes, and in the various modifications, and are sometimes beautifully arranged in groups, or with dog-tooth spar, blende, or calamine.

At Granby and Joplin a great deal of mining has been done, and immense quantities of mineral, ores of both lead and zinc, taken out, but the mining in South-west Missouri may be said to be comparatively in its infancy. There has probably been more mining done in Washington County that in any other county in the State. The county has been mined nearly all over, and evidences show that galena may be expected anywhere.

Zinc occurs at most of the Missouri lead mines, but not always in sufficient quantity to mine. It is mined in Washington, Jefferson, Dade, Green, Newton, and Jasper. The ores worked are blende, smithsonite, and calamine. Blende in well-defined crystals occurs at Mammoth Mines, Jefferson County, Versailles, Morgan County, and near Carthage, at Joplin, and at Stephens Mines, Jasper County. Crystallised smithsonite is found at Minersville, Jasper County, and at Granby, Newton County. Beautifully crystallized calamine is found at Valli Mines, Jefferson County, at Granby, at Joplin, and in Dade County. At Granby and Joplin calamine is found associated with greenockite, and at Granby with buratite. At Palmer Mines and at Joplin calamine is often found coating galena.

I have thus noticed the localities of such minerals as were on exhibition at the International Exhibition, 1876.

III. New Jersey.

(Extracts from the Catalogue of the Centennial Exhibit of the Geological Survey of New Jersey.)

All the larger geological formations of the United States, except the coal formation, are found in this State. They occur in parallel belts or zones,

usually some miles in breadth, which traverse the State in a north-east and south-west direction; and they are so regular in this respect that a person may travel on a north-east and south-west road from one side of the State to the other and see but a single geological formation. But, on the contrary, if he should journey from Barnegat, on the Atlantic coast, north-west to Port Jervis, on the Delaware, he would cross every formation in the State.

The collection of rocks shown has representative specimens from the Azoic, Silurian, Devonian, Triassic, Cretaceous, Tertiary, Drift, and Recent Formations.

Azoic Formations.—The Azoic formations are the Archæan of Dana, and the Laurentian of Canada. They are the oldest of the geological series, and are made up of granitic, gneissic, and other crystalline rocks, and contain no fossils. They are the material composing the mountain ranges which extend across the north-western part of the State, and are known by the names of Ramapo, Warwick, Hamburg, Pochuck, Schooley's, Mine, Musconetcong, Scott's, and other mountains. They extend to and beyond the North River in New York, where they are known as the Highlands, and in Pennsylvania their extension is known as the South Mountain. They cover an area of about 772 square miles in New Jersey, and they contain all the mines of magnetic iron ore.

Silurian Formations.—These formations are the lowest and oldest rocks of the geological series which contain fossils. The rocks are sandstones, limestones, and slates. These formations occupy many of the valleys between the mountains of Azoic rock and the whole of a belt of country fifteen or twenty miles wide, north-west of and adjoining these mountains. A marked feature of this district is the high, narrow, and long ridge which is near its north-western border, and which is known in New Jersey as the Blue Mountain, in New York as the Shawangunk Mountain, and in Pennsylvania as the Kittatinny Mountain. The divisions of the Silurian are the Potsdam sandstone, including the Green Pond Mountain conglomerate, which is the oldest; and then, in order, the Magnesian limestone, the Trenton limestone, the Hudson River slates, the Oneida conglomerate, the Medina sandstone, and the Lower Helderberg, and associated limestones. The rich farming lands of Sussex and Warren Counties are on the Magnesian limestone, and the grazing and dairying lands are on the Hudson River slates. The area covered by these formations is about 650 square miles.

Devonian Formations.—These formations have but a very limited exposure in New Jersey, along the Delaware, from the New York State line to the Wallpack Bend. The area included is about 40 square miles. There are some valuable limestones and some good soils, but much of it is incumbered with drift.

Cretaceous Formations.—These formations are characterised by containing extensive and valuable beds of fine clay and greensand. The belt of the country in which they occur adjoins the Triassic on its north-west border, and extends from the Raritan Bay and the seaside to the Delaware River near Salem. It is nearly 90 miles long and from 12 to 15 miles wide, and has an area of 1,491 square miles. The white clays occupy the north-western side of the belt, and the greensand marls the south-eastern side. The clays are extensively used for the commoner kinds of pottery, and fire-bricks made from them are among the most infusible known, and they are more used for refractory materials than any other in the country. The marls have been largely used by farmers, and they have produced most remarkable effects on the soil, restoring fertility to worn-out and abandoned fields, and bringing productiveness and thrift to the whole district where they can be used.

Tertiary Formations.—The southern portion of the State is mainly occupied by these formations. They consist of beds of sand and clay, and the surface is covered with a thin soil, which is not naturally very productive. Some of the clays contain shells enough to be designated as marls; and extensive beds of the purest of white sand, for glass-makers' use, are common. Some good farms are found on this formation, and along its borders are found some of the best farms in the State.

The drift materials are scattered very unevenly over the different formations throughout the State.

RECENT FORMATIONS.—Under this head are enumerated fossil oyster-shells, shells, infusorial earth, shell-marl, calcareous sinter, beach-pebbles and beach-sand.

IV. SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA, MODELS AND MAPS ON EXHIBITION.

By JOHN H. HARDEN.

1. An unfinished model of part of the (northern anthracite) Wyoming and Lackawanna coalfields in the county of Luzerne, Pennsylvania. Area, 80 square miles. Total area of the coalfields 198 square miles (Rogers). Production in 1875, eleven and a half million tons. Size of model, 180×42 inches. Scale, $\frac{1}{12000}$, vertical and horizontal alike. Constructed by John H. Harden, assisted by the students, class '76, Towne Scientific School, University of Pennsylvania, Philadelphia.

2. Model of the Schuylkill Water Gap, in the Blue Mountains, near Port Clinton, in the counties of Schuylkill and Berks, Pennsylvania. Size, 28×38 inches. Scale, $\frac{1}{4800}$. Constructed by John H. Harden, assisted by the students, from surveys made by Henry M. Chance.

3. Model of the Lehigh Water Gap, in the Blue Mountains. Section coloured, showing the formation and geological structure. Size, 21×25 inches. Scale, $\frac{1}{4800}$. Constructed by Charles E. Hall.

4. Model of Black Log Gap and Environs of Orbisonia, Huntingdon County, Pennsylvania. Coloured, showing the geology from the (Lower Silurian) calciferous limestone up to the (Devonian) Hamilton sandstone, including the Clinton fossil ore, and the hematites of the Marcellus and Oriskany. Size, 21×25 inches. Scale, $\frac{1}{9600}$. Constructed by Charles A. Ashburner.

5. Model same as last. Coloured, to show the surface topography. Same author.

6. Model of the Delaware Water Gap, in the Blue Mountains. Coloured, showing the geological formations, with their difference of dip on the two sides of the river. Size, 27×25 inches. Scale, $\frac{1}{9600}$. Constructed by Henry M. Chance.

7. Model same as last. Coloured, to show the surface topography. Same author.

8. Model of Logan Gap, in Jack's Mountain. Coloured. Showing formations and structure. Size, 18×18 inches. Scale, $\frac{1}{4800}$. Constructed by Charles E. Billin.

9. Model of the Ironton Railroad Company's brown hematite iron ore mine, Lehigh County, Pennsylvania. Coloured, to show the position of the ore in the mine (quarry). Size, 52×18 inches. Scale, $\frac{1}{600}$. Constructed by Ellis Clerk, jun.

10. Model of Oak Hill Colliery (anthracite), Drifts Nos. 1 and 2, near Scranton, Luzerne County, Pennsylvania. Constructed by John H. Harden. Size, 10× 13 inches. Scale, $\frac{1}{1200}$.

MAPS.—A large number of the original maps of the survey, too numerous to mention in detail. (See Reports.)

Sections of the coal measures and other drawings, made by students, class of '76.

A map of the Wilkes-Barre Coal and Iron Company's (now the Lehigh and Wilkes-Barre Coal Company) lands and mines, lying on the south side of the Susquehanna River, in the townships of Wilkes-Barre and Hanover, extending from the Diamond to the Sugar Notch Mines, including the mines of the Franklin and New Jersey Coal Companies. Size of map, 180×42. Scale, $\frac{1}{2400}$. Surveys complete to January 1872.

LITHOLOGICAL AND PALÆONTOLOGICAL COLLECTIONS.

By C. E. HALL.

The collection consisted of a complete series of the rocks from the crystalline schists to the coal-measures inclusive, together with a series of specimens of the new red sandstone.

Huronian (?) Crystalline Schists.—This series of Pennsylvania was represented by the leading varieties of feldspathic schists and gneisses, mica and hornblende schists, serpentines, talcose schists, damourite slates, and corundum.

Potsdam Sandstone (I.)—Represented by several specimens of dark reddish and light yellow compact sandstones, with tubes of *Scolithus linearis*.

Cambrian Limestones (II.)—The following recognised subdivisions, together with their characteristic fossils:

Calciferous sand-rock, overlying the Potsdam sandstone; sandy dolomites.

Chazy limestone; dark shaly limestone, with a genus of the trilobite *asaphus*.

Black River limestone; dolomitic limestones, with the fossil *Gonioceras anceps*, with some less characteristic fossils.

Trenton limestone (recognisable throughout Pennsylvania), varieties of compact and shaly limestones, together with a large number of specimens showing the occurrence of the fossils throughout the series.

Utica Slate and Hudson River Shales (III.)—Ferruginous slates and shales, with the few varieties of fossils found in them.

Oneida Conglomerate and Medina Sandstone (IV.)—The principal varieties of conglomerate and conglomeratic sandstones and sandstones. Several large slabs showing ripple-marks, and specimens of the fucoid *Arthrophycus Harlani*.

Clinton Group, or Fossil Ore Range (V.)—Specimens fully representing the group from its base to the top, including sandstones, shales, limestones, and ores, with their included fossils.

Water-lime and Lower Helderberg Groups (VI.)—Hydraulic limestones, lime-shales, and limestones of the leading varieties, including characteristic fossils.

Oriskany Sandstone (VII.)—Sandstones, shales, cherts, &c., including a number of characteristic fossils.

Hamilton and Chemung Groups (VIII.)—Slates, shales, sandstones, limestones, and ferruginous sandstones, principally from the northern portion of the State. The fossils of these two groups fully represented.

From the Oil Regions.—Sandstones, shales, and conglomerates from various horizons, together with many fine specimens of plants.

Coal-Measures.—A series of specimens of anthracite, bituminous, and cannel coals, together with shales and sandstones, showing many of the principal coal plants.

Iron Ores.—The principal collection of the ores was from the Clinton group, this being an important belt throughout the State. Some of the limonites from different parts of the State and from various horizons were also represented.

A complete series of the measures from the Cambrian limestones to the coal-measures, illustrating a model of the vicinity of Orbisonia, in Huntingdon County.

Chemical Composition of Pennsylvania Petroleum.

Among the material on exhibition by the "Second Geological Survey of Pennsylvania" was placed a set of chemical preparations illustrative of the composition of Pennsylvania petroleum. This set had been prepared by Professor C. Schorlemmer, F.R.S., of Owen's College, Manchester, England, and was placed on exhibition by Professor Samuel P. Sadtler, of the University of Pennsylvania. The preparations were of very great scientific interest, both in themselves and because they had all been prepared from Pennsylvania petroleum. All were chemically pure, and many were unique specimens, having been as yet prepared only from this material. The importance of this exhibit in a scientific direction was recognised by the Judges of the group on chemicals, in the award of a medal to Professor Schorlemmer, the manufacturer of the preparations.

The following is a list of the exhibit:

Chemical composition of Petroleum, illustrated by a set of its ingredients and derivatives, prepared by Professor C. Schorlemmer, F.R.S., Owen's College, Manchester, England.

I. Paraffine Series of Hydrocarbons.

1.	Normal pentane	boiling point 37°– 39° C.
2.	Normal hexane	„ „ 68– 69 C.
3.	Normal heptane	„ „ 98– 99 C.
4.	Normal octane	„ „ 123–125 C.
5.	Iso-pentane	„ „ 29– 30 C.
6.	Iso-hexane	„ „ 60– 62 C.
7.	Iso-heptane	„ „ 89– 91 C.

II. Derivatives of the Olefine Series of Hydrocarbons.

1.	Bromides from petroleum	boiling at 90°–120° C.
2.	Bromides „ „	„ 120–125 C.
3.	Bromides „ „	„ 140–150 C.

III. Derivatives of the Benzine Series of Hydrocarbons.

1.	Dinitrobenzine from petroleum	boiling at 50°– 60° C.
2.	Dinitrobenzine „ „	„ 60– 70 C.
3.	Dinitrobenzine „ „	„ 70– 80 C.
4.	Dinitrotoluene „ „	„ 100–110 C.
5.	Dinitrotoluene „ „	„ 110–120 C.
6.	Nitro-compounds from petroleum	„ 120–130 C.
7.	Nitro-compounds „ „	„ 130–140 C.
8.	Nitro-compounds „ „	„ 140–150 C.
9.	Nitrotoluene „ „	„ —
10.	Liquid nitro-compounds from petroleum	„ 110–120 C.
11.	Liquid nitro-compounds „ „	„ 130–140 C.

V. MEXICO.

By G. C. Broadhead.

Quoting from Mariano Barcena, in the Catalogue of Mexican exhibits:—

"There are three classes of rocks found in the mineral veins of Mexico:—

"1. Compact mesozoic limestone.

"2. Slate and sandstone.

"3. Metalliferous porphyry, probably of tertiary age.

"Types of these formations are to be found in the States of Queretaro, Guanaxuato, and Hidalgo. Many mountains composed of these rocks can be seen in almost all the States. Argentiferous galena and tetrahedrite are found in the first; polybasite and pyrargyrite in the second; and sulphuret of silver, argentiferous galena, and blende in the third."

A very useful geological study was the collection of Mariano Barcena, accompanied with maps and plates illustrating the volcanic phenomena of Ceboruco, in Jalisco.

Among the Mexican minerals were observed arsenic from Hidalgo and Michoacan, where it occurs in combination with sulphur and with iron.

Bismuth is found in the States of Guanaxuato and San Luis Potosi, in the form of sulphurets, selenides, tellurides, and carbonates.

Native copper is said to abound in Chihuahua. Other copper ores, including cuprite, chalcopyrite, azurite, chalcocite, and malachite are found in Vera Cruz, Michoacan, Zacatecas, San Luis Potosi, and Aguascalientes.

Gold is chiefly obtained from Oaxaca, Mexico, Guerrero, Chihuahua, Michoacan, and Lower California.

Iron exists in all the mineral districts of Mexico. The mountain of Mercado, near the city of Durango, is almost wholly formed of iron, and includes finely-crystallised martite.

The mountain of Cangando contains large masses of magnetic iron, and the mountain itself is of metamorphic cretaceous limestone.

Galenite, cerussite, minium, and pyromorphite were exhibited.

Cinnabar is an abundant ore of Mexico, of which San Luis Potosi, Queretaro, and Guerrero furnished samples. The various mercury ores include gaudalcazarite and livingstonite, the latter a sulphuret of antimony and silver, somewhat resembling stibnite, from Huitzuco, in the State of Guerrero.

Silver is found almost all over Mexico, as well in its native state as also sulphide, chloride, bromide, iodide, arsenite, antimonide, and mixed with galena, blende, and pyrite.

Sulphur is abundant. Large and fine-looking masses from Popocatapetl were on exhibition.

Deposits of bituminous and anthracite coal, bitumen, and graphite are said to abound. Coal is found in the States of Tampico, Vera Cruz, Hidalgo, and La Huasteca; lignite in Guerrero, Chihuahua, Puebla, and Hidalgo. Crystalline graphite occurs quite pure in the district of Molango, State of Hidalgo; compact graphite at Animas, in the State of Sonora.

Fine and precious opals are often met with in Mexico, the former in the districts of Zimapan, Esperanza, &c.; the latter in Esperanza, Amealco, and Real del Monte.

VI. BRAZIL.

By G. C. Broadhead.

The geological survey now in progress proves the existence of the chief formations of North America and Europe, but as yet we possess no particular information from that source, but our authority for mineral localities must be derived chiefly from a pamphlet published under the authority of the Brazilian Government for use at the International Exhibition at Philadelphia. We thus learn that the entire southern coast of the empire between 12° and 30° south latitude is formed almost exclusively of igneous rocks, including granite, gneiss, diorite, quartzite, porphyry, with beautiful varieties of syenite.

In the interior are fine limestones and large deposits of plastic clay. Near Rio Janeiro are whitish gneisses, dark porphyritic granites, and dykes of variegated porphyry.

The Rio Grande marbles used in works of art are from the provinces of Sao Pedro do Rio Grande do Sul, Minas Geraes, Sao Paulo, and Bahia; also certain marbles, the most remarkable from the municipality of Sao Roque, near the capital of Sao Paulo. Lime is chiefly made from oyster shells and corals. Potter's clay exists throughout the whole of the empire, resulting from the decomposition of certain rocks; some is also obtained from alluvial deposits; and deposits of white clay are also found.

Kaolin is found in Rio Janeiro and most of the provinces, particularly in Parana. Refractory clay is obtained in Ceara, of which are made excellent crucibles.

Near Pernambuco and Bahia are rich deposits of cretaceous fossils, including fishes. The carboniferous formation occupies a large area of the empire, and true coal is found in some of the provinces; the most important mines being in the south part of Sao Pedro do Rio Grande do Sul, and Santa Catherina.

Abundant lignite deposits occur in all the provinces, the best in Santa Catherina, Sao Pedro do Rio Grande do Sul, and Minas Garaes.

Bituminous schists have been discovered in most of the provinces, and in Bahia oil is manufactured from them.

Peat from Macahè and Campos has been used in sugar-furnaces with good results.

Graphite is only abundant in Ceara. Sulphur is abundant in Minas Geraes.

Saltpetre is abundant in the calcareous caves of Minas Geraes, Piauhy, Ceara, Matto Grosso, and Bahia.

Alum is found in large quantities in Parana, Minas Geraes, Piauhy, and Ceara, where there are lignites and bituminous schists.

Rock salt is obtained in Matto Grosso and Goyaz, Parana, Bahia, and Piauhy.

Various thermal, saline, alkaline, chalybeate, gaseous, and other springs are found in various portions of the empire.

Diamonds are found in Minas Geraes, along the Espinhaço range, in provinces of Goyaz, Matto Grosso, Parana, Sao Pedro do Rio Grande do Sul, and Sao Paulo. The mines are the property of private individuals.

Emeralds, euclases, sapphires, rubies, topazes, beryls, black, blue, and green tourmalines, called Brazilian emeralds, are found especially in Minas Geraes, where the common zircon is also found. Imperfect garnets are met with everywhere. Rock-crystals in great purity and large size are exported principally from Minas Geraes, Goyaz, Sao Paulo, and Parana, whence also come fine and large amethysts. Opals, chalcedonies, agates, and jaspers are met with throughout the interior, but the chief export is from Sao Pedro do Rio Grande do Sul. Pure crystals and valuable veins of yellow quartz exist in Goyaz.

Gold is a natural product of every province, but the chief auriferous regions are in Minas Geraes, where it occurs in itacolumnite. The municipal districts of Caçapava, Rio Pardo, Santa Marie, and Cruz Alta, in the province of Sao Pedro do Rio Grande do Sul, are undoubtedly auriferous. It is chiefly found in compact quartz or quartzite veins in primitive or micaceous ironstone; also in alluvial soils; and, mixed with gold, in these sands, are also found platinum, iridium, and palladium, tellurium, bismuth, and arsenical pyrites.

Silver is found with many galenas, existing in all the provinces, but its proportion is always less than 1 per cent. of the lead. It forms 2½ per cent. of the copper ores of the district of Caçapava, in the province of Sao Pedro do Rio Grande do Sul.

Mercury is found in rich quantity in the province of Parana, and is also found in Santa Catherina, and in the metallic state in Sao Paulo.

Copper is found in Matto Grosso, Goyaz, Minas Geraes, Bahia, Maranhao, Ceara, and Rio Grande do Sul.

Manganese is from Minas Geraes and Bahia. A very little tin has been found in the sands of Paropeba, Minas Geraes, and in some granites of Rio Janeiro.

Zinc is found in the Ibiapaba range, province of Ceara.

Galena in large quantities is found especially in Sao Paulo, Sao Pedro do Rio Grande do Sul, Minas Geraes, Rio Janeiro, Parahiba do Norte, Bahia, Santa Catherina, Ceara, Maranhao, and Piauhy. Chromate of lead is abundant at Congonhas de Campo, in Minas Geraes. The most important lead mine is that of the river Abaetè, from which silver is also extracted.

Antimony is found in Minas Geraes, Espirito Santo, Sao Paulo, and Parana. Bismuth and arsenic are found in Minas Geraes.

Immense deposits of iron occur in the provinces of Minas Geraes, especially in the Itabira range. In the northern provinces, in the interior of Minas Geraes, Sao Pedro do Rio Grande do Sul, and Parana the quantity of iron is said to be enormous. There are also large quantities of oligistic, magnetic, and micaceous iron. The richest mines, which do not constitute an independent formation, are lodes such as those of Sao Joao d'Ipanema, and some in the provinces of Alagoas, Ceara, Rio Grande do Norte, and Parahyba.

The magnetic ores of Brazil contain 72½ per cent. of iron, the other good ores 70 per cent., and inferior qualities 25 to 20 per cent.

ABSTRACT OF THE REPORTS ON GROUP I.

Prof. Francis A. Walker, *Chief of the Bureau of Awards.*

Sir,—We have herewith the honour of presenting our awards on the various exhibits submitted to our examination, and in doing so, we respectfully ask to be permitted to offer a few remarks on the manner in which the duty imposed upon us has been discharged.

The articles on the merits of which we had to pronounce a verdict were not only of vast extent, but they comprised subject matter of a very diversified nature.

There remained, therefore, no alternative but to apportion the labour of actual examination to those individual members of our group who, from previous experience and actual knowledge, were best qualified to form a correct opinion on the respective merits of the objects placed in the buildings prepared for their reception.

Although the reports from the various sub-sections were brought up for confirmation at a general meeting of the Judges, and in most cases the exhibits themselves were visited by other members of our body, it must be understood that the responsibility of the various awards necessarily rests with those gentlemen at whose recommendation in the first instance they were made.

Some misapprehension seems to have prevailed in the minds of many exhibitors as to the line of conduct to be pursued in asking for the opinion of Judges on the articles displayed.

For instance, speaking in a general way, it is impossible to form a proper estimate of the value of a block of coal or of a bar of iron by a mere inspection of external appearances. It might be well for future exhibitors upon such occasions to take a lesson from the admirable way in which Sweden assisted us in the performance of our duty. Maps and geological charts indicated the locality of the works and position of the mines. Analyses of the raw materials as well as of the finished products, along with the usual tests of strength and ductility, enabled us at one visit to pronounce decisively on their merits. Many other manufacturers, both American and foreign, at great expense to themselves and by the exercise of great ingenuity, presented their exhibits in a most creditable and striking manner.

On the other hand, several exhibitors left us without means of arriving at any positive conclusion as to the character of the article submitted for our examination, and, as a matter of course, we have been unable to recommend its being distinguished by any mark of approbation.

In certain cases, where the product is a mere raw material of extensive occurrence, we would refer you to the system adopted under your own sanction of making a special report in their favour.

The same plan has been pursued when the exhibits were clearly of a representative character, such as the minerals and iron from the Lehigh Valley, the Hanging Rock region, &c.

We avail ourselves also of this opportunity of recommending to your favourable notice the way in which the British colonies have offered for general inspection the natural resources they possess, as well as for the proofs which are given of the immense progress made recently in their development.

In close relation with the duties undertaken by the sub-section of our group having charge of the exhibition of iron and steel is a question connected with the nomenclature of these two forms of the same substance, which, in our opinion, may demand public consideration.

The present appears to us a favourable opportunity of directing international attention to the subject, particularly as those engaged in the manufacture of these substances feel that some change of name is required.

A committee, consisting of Messrs. Bell, Tunner, Gruner, Akerman, Wedding, Egleston, and Holley, were appointed by the American Institute of Mining Engineers at its June meeting, 1876, to consider whether any, and if any, what alteration of name should be introduced into commerce so as to distinguish between articles incorrectly described by their present designations. This committee agreed upon the following report:

First. That the term "steel," by which these soft products are commercially and professionally known in England and in the United States, does not completely distinguish them from that substance formerly known as steel, and which would "harden" and "temper."

Second. A nomenclature recognized in all languages seems desirable as well for commercial as for scientific purposes, especially as lawsuits already commenced depend on the meaning of the term "steel."

Third. Although homogeneity due to fusion is usually recognized, and is by this committee recognized as the most definitive characteristic of both hard and soft steel, this quality may be equally well expressed in other terms, thus leaving the old term "steel" to define the malleable compounds of iron which are susceptible of "hardening" and "tempering."

The Committee therefore resolved to recommend the following nomenclature :—

First. That all malleable compounds of iron with its ordinary ingredients, which are aggregated from pasty masses or from piled bars, or from any forms of iron not in a fluid state, and which will not sensibly harden or temper, and which generally resemble what is now called "wrought or malleable iron," shall be called *weld iron.*

Second. That such compounds, when they will from any cause "harden and temper," and which resemble what is now called "puddled steel," shall be called *weld steel.*

Third. That all compounds of iron with its ordinary ingredients, which have been cast from the fluid state into malleable masses, and which will not sensibly harden and temper by being quenched in water while at a red heat, shall be called *ingot iron.*

Fourth.—That all such compounds, when they will from any cause so "harden and temper," shall be called *ingot steel.*

While admitting that the style of nomenclature recommended will, in the case of substances sliding imperceptibly into each, fail to draw a well-defined line between what is iron and what is steel, we believe that the inconveniences of the present system will be to a great extent avoided by the new nomenclature, and we recommend its adoption.

We would also respectfully call the attention of the Commissioners to the following resolution passed by our group :—

Resolved, That the Judges of Group I., having during these examinations been repeatedly reminded of the embarrassments, both in trade and science, arising from a diversity of weights and measures throughout the world, take this occasion to strongly recommend through the Centennial Commission the establishment of a uniform international system of weights and measures.

I. LOWTHIAN BELL, *President.*

FRED'K PRIME, JR., *Secretary.*

NOTE BY THE EDITOR.

In view of the general and exhaustive discussion of the question of silver production during the past five years, both here and in Europe, and the vast amount of information embodied in official documents and private treatises on this subject, the Editor has not deemed it essential that the present series of reports should embrace a paper on this topic.

Whatever might be here presented must, from the contracted space allotted to it, be less complete than what is easily to be found elsewhere, and would, moreover, from the necessity of the case, be merely made up of second-hand material.

The subject of gold production was assigned by the Judges of Group I. to Hon. S. B. Axtell, of New Mexico. The following letter contains Governor Axtell's reasons for not presenting a report on that subject :—

"SANTA FÉ, NEW MEXICO, February 14, 1877.

"GENERAL F. A. WALKER,

"New Haven, Conn.

"SIR,—I was assigned by the Chairman of Group I. to report upon the metallurgy and extraction of gold, as exhibited in the International Exhibition of 1876 at Philadelphia. On referring to the Report of the American Commissioners to the Paris Exposition of 1867 on this subject, I find it so completely full and exhaustive upon this topic, that to write anything more would be impossible without repeating that Report. Since that Report was published there have been no important discoveries of gold fields nor important inventions for extracting the metal. I beg, therefore, to refer to that Report as containing all the facts known upon this subject.

"Very respectfully,

"S. B. AXTELL."

GENERAL REPORT

ON

GROUP VI.

TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY.

JUDGES.

American.	*Foreign.*
Prof. Wm. H. Brewer, Yale College, New Haven, Conn.	Mr. John R. West, Chili.
Hon. J. M. Bennett, Weston, Lewis County, W. Va.	M. Rodrigues de Vasconcellos, Portugal.
Prof. J. S. Newberry, Columbia College, New York.	Dr. José de Saldanha, Brazil.

The following named Judges were temporarily assigned from other groups to assist to the examination of the classes attached to their respective names.

Prof. W. H. Chandler.—Raw rubber.
Don Fermin Rosillo.—Products of the Philippine Islands.

GENERAL REPORT.

TIMBER, WORKED LUMBER, PARTS OF BUILDINGS, FORESTRY.

In the *Grouping for the Judges' Work*, eight classes were referred to Group VI., arranged in eleven sub-classes, each of which contained several kinds of objects. To these were afterwards added several other sub-classes, in whole or in part. No statistics have been prepared of the actual number of exhibits. For our present purpose, the objects originally referred to the group may be considered in four great divisions, viz.:

1. The crude products of forests, trees, and shrubs, including certain scientific and illustrative collections, lumber, timber, woods, and various economic or commercial raw material. This excludes cultivated fruits, but includes the woods of cultivated fruit-trees where used for economic purposes.
2. Certain manufactured parts of buildings and structures made of wood, as prepared for market, and specimens of carpentry.
3. Timber and lumber prepared to resist combustion and decay.
4. Illustrations of the art and science of tree-planting, tree-culture, and forestry, also literature, maps, and statistics relating to forestry.

A careful classification and elaboration of these four orders into divisions and subdivisions would give about fifty ultimate parts or groups, each of which may consist of the products of few or of many species of trees. We shall consider the four principal divisions.

1.—*Woods, Timbers, Lumber, and Raw Forest-Products.*

Wood is one of the few prime necessities of society, and is the raw material for a greater variety of manufactures than any other natural product. Considered as a whole, it is a product of every habitable country, with the very limited exception of a few desert and arctic regions inhabited by savages. The kinds and species vary with the geographical locality, the extremely useful timbers being for the most part the product of regions with a temperate climate, where the forests are more generally composed of "social" or "gregarious" species; and the very ornamental woods coming largely from tropical countries, where the number of woody species is much greater but the social or gregarious fewer. While the actual number of useful species is as great or greater in the tropics than in temperate climates, the economic production is less, because of a smaller local demand. As a whole, the harder, heavier, more highly-coloured, and more fragrant woods are from the tropics, and these regions furnish a larger variety of such other useful raw materials as barks, gums, medicinal extracts, &c.

In this general notice no distinction will be drawn between the woods of Class 600, which relate to museum collections and the woods of construction, and of Class 601, which relate to ornamental and furniture woods. No such distinction was drawn in the exhibits, except in a few instances, neither is the distinction drawn in commerce except as it is caused by production and transportation, nor is it found in nature. In the Ohio Valley, or farther west, the black-walnut is used by one generation for the commonest purposes, even for farm fence-rails and cheap fuel, and with the next generation it becomes the most fashionable and costly of native ornamental woods. Chestnut and swamp-ash are other familiar examples at home; while any commercial foreign wood becomes "ornamental" in almost the same ratio in which it becomes rare or costly.

The display of woods, timber, and lumber in the Exhibition was very large. The larger number of exhibits were what we will for convenience call museum exhibits, that is, collections of specimens of wood in other form than as actual timber, lumber, or fuel. Many of them were parts of larger collective exhibits containing woods, other forest-products, timbers, lumber, veneers, fuels, fibres gums, resins, barks, &c. These usually represent some county or district

One hundred and thirty-four nations, states, territories, colonies, provinces. districts, or municipalities were represented in Classes 600 and 601, one hundred and four of which were represented officially by collections illustrating their local woods by what are here called museum specimens. These were shown through a variety of agencies,—by general or local governments, departments of governments, surveys, local committees, local boards, societies, associations, botanic gardens, universities, schools, and persons acting in an official capacity. The actual number of such collections cannot be given exactly, as several local collections were often combined into larger ones representing a state or nation. Besides the official exhibits of woods, there were many, similar in character, by private exhibitors, the whole number of exhibits amounting to four hundred or more collections, containing an estimated aggregate of at least fifteen or twenty thousand specimens. Only a few collections of this large number can be here considered, and all the crude forest-products as well as museum collections will be considered together. Under the general terms "timber" and "lumber" are included all forms of merchantable woods, other than fuel and museum specimens, as they come to market, whether as logs in the rough, scaled or hewn, or pieces sawn, split, riven, cut, sliced, or shaved, all of which forms were found in the Exhibition.

Neither the number of specimens nor the number of species in a collection is any index of its economic importance, as some countries are naturally vastly richer in woody species than others, without a corresponding difference in the richness of their respective timber resources. Thus, the New World is richer in tree-species than the Old. We have, in the United States, over three hundred species of indigenous trees which grow to a height of thirty feet or more; while in the British Isles there are, according to Lindley, but twenty-nine; in France, according to Michaux, thirty (other French authorities say thirty-four); and in Germany scarcely more. We see from this how it may be that an imperfect collection of the native woods of a single county in the United States might contain more species than a complete collection of the native woods of all Europe. With certain island provinces this fact may be still more forcibly seen, where immense economic interests may centre in a very limited number of native species of woods. With this introduction we pass to some of the features of the Exhibition.

The United States had the largest and most complete collection of woods, so far as regards species, in the Exhibition. It was exhibited by the Department of Agriculture, and brought together and arranged under the direction of the botanist of the Department, Dr. George Vasey. America has long been described by geographers and naturalists as the wooded continent, distinguished for the luxuriance and extent of its forests and the number of its arboreal species. Of the three or four hundred species of trees of thirty feet in height or more, about one hundred and twenty species attain a height of one hundred feet, twelve of two hundred feet, and five or six a height of three hundred feet or more. There are at least three forestral floras, each rich in tree-species, and the collection contained nearly every indigenous species known to the botanist as occurring within the United States, and also some of the larger shrubs. Many of the species were shown in several geographical varieties. Most of them were accompanied with foliage, flowers, and fruit. The printed annotated catalogue shows four hundred and nineteen species, a few of which, however, are not strictly trees, but rather important shrubs.

The United States Naval Department exhibited ship-timber. Some pieces artificially bent were especially interesting.

Except as represented in the general collection above spoken of, many of the States and Territories had no exhibits of crude forest-products whatever. Twenty-one States and Territories had such exhibits, however, and seventeen had some kind of official exhibit of native woods, timbers, or lumber. The others were represented only by private exhibits, and some of the States noted for their trees were entirely unrepresented.

From Delaware was a large collection, consisting of museum specimens appropriately labelled, also ship-knees and timbers, and many rough sections of trees, some of great size, all carefully labelled.

From Illinois were several collections, the largest and most nearly complete being that by the State Industrial University at Champaign. This consisted of nearly two hundred specimens, mostly named, many of them accompanied with notes on range, abundance, and size.

From Indiana appeared a collection of native woods in rough sections. It embraced only a part of the timber-species of the State, but some of them were of large growth and represented valuable timber-trees.

From Iowa was a collection of about one hundred and sixty catalogue numbers, some of the specimens of large growth, some undressed, others dressed, varnished, and finished to show adaptability for ornamental uses; also, cultivated woods.

Kansas had a large collection, mostly of cross-sections, especially interesting as showing the rate of growth of several species artificially planted. Of the indigenous growths, black-walnut, cotton-wood, and sycamore were shown in cross-sections over five feet in diameter.

The State of Michigan, and the Agricultural College at Lansing, exhibited large and interesting collections of the woods of that State. They contained cross-sections, blocks, dressed and polished boards, miscellaneous pieces and arboreal curiosities, planks, and marketable lumber. The printed catalogue, by Prof. J. W. Beal, contained much information relative to the native woods of the State, made more interesting by the fact that at present this State brings more lumber to market than any other in the Union. In a list of dimensions of native trees, twelve species were named with diameters of five feet and over, conspicuous among them being white-pine, six and a half feet; white-oak, eight and a third feet; cotton-wood, ten feet; black-walnut and button-wood, each eleven feet. There were also fine exhibits of lumber and of rough logs.

From Ohio was a private exhibit of white pine of great excellence; and from Wisconsin a considerable, but by no means complete, collection of woods. Some of the timber-trees of Wisconsin were finely shown.

The exhibit of West Virginia was relatively the fullest of any of the State collections. Local and county collections, museum specimens, and the contributions of many private persons were combined in one grand State exhibit under the direction and supervision of Mr. M. F. Maury, who prepared a printed description. The exhibit consisted of, 1st, about eighty species, all those known to be indigenous to the State, shown in beautiful museum specimens, arranged like large volumes in a library; 2d, sixty-three museum planks varnished and polished to show adaptability to furniture and ornamental work; 3d, sawn and split lumber; 4th, rough cross-sections to illustrate size of natural growth; 5th, veneers of several native species, both as prepared for market and in the finished work. Owing to the difficulty of transportation, the largest specimens intended for the Exhibition were ultimately left at home; but the following sixteen species were shown in sections of three to five feet diameter,—white-ash, beech, butternut, black-walnut, chestnut, white-elm, white-hickory, red-hickory, white-oak, red-oak, chestnut-oak, poplar, red-birch, sugar-maple, sycamore, and tulip-tree, and such valuable woods as locust, wild-cherry, sassafras, silver-maple, &c., of relatively large size.

The only considerable State exhibit of woods from the Pacific States was from Oregon; a portion of the specimens were especially impressive as exhibiting the gigantic size of some of the trees and the immense timber resources of the region. Thus, of yellow-fir (*Abies grandis*) two sections were shown taken from the same tree, the first six feet ten and a half inches in diameter exclusive of bark, taken "one hundred and thirty feet from the ground;" the other five feet ten inches, taken "two hundred feet from the ground," with the statement that the tree was three hundred and twenty-one feet high, fifteen and three-quarters feet in diameter at the butt, and that the timber of that species is "good for ship-building." A section of tide-land spruce (*Abies menziesii*), taken "ninety-eight feet from the ground," was six feet ten inches in diameter, and the tree is stated to have been three hundred and eighteen feet high, and sixteen feet in diameter at the butt. With an exhibit of shingles made from this species is the statement, "This tree made 100 M. [100,000] shingles, and the branches and other parts not used in shingles made fifty-eight cords of wood." A section of Oregon red cedar (*Thuja gigantea*), more than five feet in diameter, has the accompanying statement, that it was "taken out of the tree one hundred and eighteen feet above the ground and two feet seven inches from the centre" (that is, from one side, and not across the centre of the tree, and therefore showing much less than the actual diameter at that point), and that "the diameter of the tree was twenty-two feet, length

of the tree three hundred and twenty-five feet." There were also exhibits illustrating great size in the original trees, with specimens of other timber and ornamental woods. Specimens of the Oregon maple (*Acer macrophyl'um*) "burled," both in the rough and wrought, were exhibited to show its capability for ornamental uses, some of the latter having great beauty.

Of crude forest-products other than woods, lumber, and timber, very little was shown from the United States, except a few articles to be noticed later. We may here, however, speak of a collection of woods of trees and shrubs of the United States, by Mr. Thomas Meehan, of Germantown, Pennsylvania. It purported to contain three hundred and fifty species, and is, so far as known to us, the fullest such collection yet exhibited.

In several of the State buildings a few of the woods native to the State were shown in construction.

Argentine Republic.

The woods of the Argentine Republic were represented in about 50 collections, seventeen provinces being locally represented by official exhibits. The rich mass of material was exhibited as a whole, and embraced many hundreds of specimens in a variety of forms, sections rough and polished, and a great number of museum specimens illustrating every variety of grain and finish, accompanied with pictorial illustrations. With these was exhibited a rich and varied collection of other forest-products, such as gums, dye-woods, barks, fibres, &c.

Brazil.

From Brazil were about thirty collections of woods, twelve states and districts being officially represented through local committees or their official agencies. These, with some of the private collections, were arranged in the Exhibition so as to show the forest resources of the Empire as a whole. Many were large-sized museum specimens, others in truncheons, sticks, planks, &c., and many of them polished to show their appearance when finished. Taken as a whole, they formed, perhaps, the most striking and attractive display of woods in the Exhibition. Large planks and boards, commercial woods, and woods used in the navy for ship-building, were also shown. The vast forests of the Amazon Valley have long been famous as the most extensive and luxuriant of the tropical forests of the world. The vast extent of the Empire, with its varieties of soil and climate, combined with the arboreal tendencies of American vegetation, have made this country especially rich in valuable woods and timbers, and a larger number of species of trees are known to botanists as indigenous to Brazil than to any other country. In the Exhibition over three hundred species were represented, including the many valuable species known to commerce, such as rose-wood, amaranth, satin-wood, &c. Professor José de Saldanha da Gama, of Rio de Janeiro, accompanied the collection with a printed catalogue of one hundred and seventeen of the more important species, with notes on their uses, their botanic names, &c., and in *Notes in regard to some Textile Plants of Brazil* is found much information on various bark-textiles. Dr. Nicolau J. Moreira, another member of the Brazilian Commission, in his *Historical Notes concerning the Vegetable Fibres, &c.*, notices various other forest-fibres of the country. Besides the woods, there was a large and varied collection of other forest-products, such as barks, gums, resins, caoutchouc, wax, medicinal barks and herbs, &c., each accompanied with the botanic name, when known, of the tree or shrub yielding the product. There were several exhibits of crude caoutchouc of first quality. The export of this product, according to official statements, has exceeded ten million pounds, annually, for the past ten years.

Great Britain.

The British Isles showed no raw forest-products, but the following British colonies or possessions were represented, either officially through local governments, institutions, or boards, or by private exhibitors, viz., Bahamas, Bermudas, British Columbia, British Guiana, Canada, Cape of Good Hope, Gold Coast, India, Jamaica, Mauritius, New Brunswick, New South Wales, New Zealand, Queensland, Straits Settlements, Seychelles, Trinidad, Tasmania, and Victoria. Some of these countries were richly represented, others but meagrely, but the interest of the exhibits bore but slight relation to the actual size of the collections. Some of these represented limited island areas,

with but few species of trees, others some of the most celebrated forests in the globe, so that a small collection might be very full and represent great economic interests, while a vastly more striking one might but meagrely represent the actual forest resources of its locality.

The nineteen colonies or possessions may, for our uses, be thrown into seven geographical groups, viz.:

a. British North America.
b. The Atlantic Islands and Guiana.
c. Africa.
d. Indian Ocean.
e. Asia.
f. Australia and Tasmania.
g. New Zealand.

a. Canada had the largest, most varied, and most attractive collection of timber and lumber in the Exhibition. The contributions of many private exhibitors were mostly arranged in a great collective exhibit, which contained nearly every form of lumber coming to market,—rough, hewn, sawn, split, and shaved,—some of the pieces of great size. The staple lumbers, especially white-pine, were noticeable for their excellence.

From the forests of British Columbia came two pieces, shown with the Canadian collection, a cross section and a plank, each more than eight feet in diameter, and both apparently of the Douglas spruce.

From New Brunswick came private exhibits of lumber, and an official description of the useful trees and shrubs of the province.

b. From British Guiana were only fibres, but the Atlantic islands, the Bermudas, Bahamas, Jamaica, and Trinidad, had each collections of woods, some of them necessarily containing few species, but those of value.

From Jamaica was a fine collection by Mr. Robert Thompson, superintendent of the Botanic Gardens at Kingston, beautifully shown, containing, besides species of less interest, several valuable tropical commercial woods (mahogany, lignum-vitæ, &c.), dye-woods, barks for textiles and tanning, gums, wax, &c., accompanied by a printed catalogue and labels, with common and botanic names and explanatory notes.

Two collections from Trinidad were especially noticeable. One by Mr. H. Prestoe, Government botanist, of sixty indigenous woods, with printed catalogue with English and botanic names, notes of size of trees, specific gravity of the woods, with barks, fibres, &c.; the other by Mr. S. Devenish, Surveyor-General, of the indigenous woods, and a few others thriving well on the island. The printed list contained two hundred and thirty-six numbers, with English, French, Spanish, and botanic names, and with the natural order to which each species belongs.

c. From the African possessions we had a small collection; from the Gold Coast and from the Cape of Good Hope a larger number of specimens, chiefly of the useful woods, and a good collection of tanning materials.

d. From Mauritius, the Seychelles, and the Straits, small collections, interesting because of their locality; and from the latter sandal-wood.

e. The collection of woods from India contained about one hundred and seventy-five specimens, all small sections, with the botanic names. As displayed, it was of scientific rather than of economic interest. In the collection of fibres were several from woody plants.

f. Australia and Tasmania were rich in woody species, some of the trees of the genus *Eucalyptus* being the tallest known, over four hundred feet high; others of the same genus have lately acquired a world-wide reputation for medicinal and sanitary virtues.

From Queensland there were several collections, aggregating some six hundred or more specimens. This portion of Australia is peculiarly rich in arboreal species, and it is claimed that these collections, large as they are, contain scarcely a fourth of the indigenous species, and "were chiefly chosen "for their economic value." We may here say, that for scientific purposes special observations were made, so far as was possible, on such specimens, in all the collections of woods in the Exhibition, to ascertain, if possible, how far the warping of woods during drying is related to their geographical distribution. As a whole, the woods of warm climates warp much less than those from cold regions, and so far as could be seen, those of Australia and Tasmania are

particularly free from this defect, although some of them "check" as badly as the woods of the Northern Hemisphere. Many of the woods are very firm, and possess the other physical properties of valuable timbers.

Apparently the collections of timber and woods from Victoria were originally very fine, but, unfortunately, they were injured in appearance by accident,—immersion in sea-water on the voyage. The Botanic Gardens of Melbourne exhibited a carpological collection of some three hundred species, another of gums and resins, a large collection of barks and fibres, and a collection of forty-five varieties of papers made from the bark, leaves, or stems of nearly as many species of plants, some of them being native woody plants.

The collections from New South Wales were especially noticeable; one from the northern districts, two hundred and twenty-seven species; the other from the southern districts, of one hundred and ninety-five species, accompanied with printed descriptions, the common and botanic names, when known, with notes on the size of the trees, uses, properties, &c. These collections, containing many large planks beautifully polished, were popularly very attractive. The recent attention paid to the planting of the *Eucalyptus* species in various parts of the world gave great interest to the beautiful planks of the woods of this genus, of which there were some fifty numbers, representing nearly as many species.

Tasmania also had a fine display of woods, containing several species of *Eucalyptus*. Mr. C. T. Creswell, of Hobart Town, exhibited seeds of three hundred and sixty-two varieties of forest-trees and flowering shrubs indigenous to Australia and Tasmania.

g. From New Zealand were several collections of woods, the aggregate number of specimens being large. They were exhibited in a variety of forms, and articles made from some of them were presented to show their appearance when finished. There was also a fine exhibit of Kauri gum, a product of the "New Zealand Pine," an article of considerable importance, twenty-six hundred tons of which are said to be exported annually, valued at nearly half a million dollars.

China.

China had several small collections, representing six localities, the whole aggregating about one hundred and fifty specimens, with the native names.

Chili.

Chili was represented by several collections, some of ingenious form.

Egypt.

Egypt had a collection of about fifty cross-sections of trees, indigenous and cultivated, mostly with their English, local, and botanic names. African ebony (from her southern possessions), ancient sycamore, and a few kinds known to ancient literature, were the features of most popular interest. With these was a peculiarly interesting collection of crude gums, partly from Nubia and partly from near the Red Sea.

Japan.

Japan had a museum collection, exhibited by the Imperial Board of Agriculture, of one hundred and three species, ingeniously and beautifully arranged. Each species was shown in a plank, presenting dressed, unvarnished, varnished, and polished surfaces, with a cross-section showing heart, sap, and bark, and with foliage, flowers, and fruit. Many of the species were also shown in extremely thin longitudinal and transverse sections fastened on paper. There was also a collection of bamboos, and articles made from them.

Liberia.

From Liberia was a small collection, only noticeable because of its fine camwood, which was shown in considerable quantity.

Mexico.

Mexico was represented by nearly thirty collections, of which thirteen were by state governments, societies, and schools, and the remainder by private

exhibitors. The collections were in a variety of forms, but it is impossible to say how many species were represented. Some of the collections were accompanied by other forest-products, and in the Mexican catalogue is a description of the more important woods, gums, resins, fibres, &c.

Netherlands East India Colonies.

From the Netherlands colonies in the East Indies were interesting collections, containing between three and four hundred species of woods, besides barks, gums, resins, caoutchouc, guttas, &c. The woods embraced dye-woods, ornamental woods, useful species, and others of a merely scientific interest, the whole accompanied by a full printed catalogue. Some special features of this exhibit will be noticed later.

Portugal.

Portugal and her colonies had more than twenty collections of woods, those of the mother-country possessing the most economic and those of the colonies more scientific interest. From Portugal came collections in various forms of all the timber-trees, specimens of the woods of construction, barks, resins, &c., and the tools and implements of forestry. Cork in all its forms and relations was well exhibited, trunks of the cork-oak, specimens of the wood, acorns, large quantities of the bark, both crude and manufactured, and in every stage of growth and manufacture, representing an enormous economic interest. Besides the official, there were about a hundred private exhibits. One manufacturer claims to produce twenty-four millions of corks annually. There was also a very large number of exhibits of nuts. The colonies of Angola, Azores, Goa, Mozambique, St. Thomas, and Cape Verde had each very large collective exhibits, containing a great variety of products. While all of these were of great interest and some very beautiful, that from Angola was perhaps the most noticeable as well as the most extensive. The beauty and variety of its woods, gums, resins, and lichens should be specially mentioned. Among the woods was a very large specimen of the wonderful *Welwitchia*, nearly three feet in diameter, the rare *Herminiera*, much lighter than cork, along with some of the very firm woods of tropical Africa, some of them much heavier than water. The collection of lichens (archils), medicinal barks and herbs, and textile barks was also large. Among the resins and copals were some half-fossil specimens of special beauty.

Russia.

From Russia were sets of specimens of the useful woods and timbers, native and cultivated, tree-seeds in quantity, and various barks, some of them manufactured into boxes, cases, and other useful and ornamental articles.

Spain.

The Spanish collections, both of the mother-country and of the colonies, were extensive and varied, and more uniform and systematic in the methods of exhibition than those of any other Government. In Spain, as well as in Portugal, the management of forests is a department of the Government, under official Forestral Engineers. The several states, districts, and colonies exhibited collections of woods which, with private exhibits, amounted to over thirty collections. In the official collections there were suites of specimens of a prescribed form, so made that each specimen showed heart, sap-wood, and bark, with the grain on the radial, tangential, oblique, and transverse sections. Thus, each specimen showed what, by some other methods, would require several separate pieces. Accompanying them were exhibits of nearly every class of crude forest-products, and also the tools used in forest-culture. The catalogue number of exhibits, including cork and nuts, amounted to over two hundred, exclusive of most of the colonial collections. The useful woods were of species common to the other countries of Southern Europe. This country, with Portugal, supplies most of the cork used throughout the world; and this product was exhibited in every stage and of every quality, the number of exhibitors being large. There were also many exhibits of nuts. From the principal colonies came rich and interesting collections. From Cuba, a solid mahogany stick twenty-two and a half feet long and twenty-five inches square.

From the Philippine Islands was a very large, varied, and especially interesting series of collections, accompanied with a *Catalogue Memoir of a Collection of Forestral Productions exhibited by the General Inspection of Forests of the Philippine Islands.* The collection was under the supervision of Dr. Sebastian Vidal, the official Forestral Engineer of the islands. The numbers as catalogued extended to over eight hundred, in addition to which there were various articles not enumerated, the catalogue having been printed at Manila and objects added after it was prepared. The collection of woods was the most complete ever made in the Islands, species new even to science being discovered in its collection. There were, according to the catalogue, 1st, two hundred and eighty-one species of woods with list of names and uses; 2nd, a collection of woods for fuel, thirty-seven numbers; 3rd, charcoals and ashes, twenty numbers; 4th, barks of fifty-nine species, with names and uses, as for tanning, dyeing, cordage, &c.; 5th, resins, gums, and oils, thirty-five catalogue numbers; 6th, fruits and seeds, seventy-five numbers; 7th, specimens of field and forest products; 8th, models of vessels and ships, with the woods of which they were made; 9th, miscellaneous forest-products, among which were a plank of tove (*Pterocarpus*) seven and one-fourth feet wide, a rattan one hundred and fifty and one-half meters (four hundred and ninety-three and one-half feet) long, a cable of black-palm fibre (*Caryota urens*) still sound after an immersion of one hundred and twenty years in sea-water, &c.

Venezuela.

From Venezuela there were a collection of one hundred species of useful woods with their names, the specimens small, however; various forest-vines; a collection of barks, fibres, gums, resins, dye-woods, and medicinal plants; also, miscellaneous forest-products, such as the milk of caoutchouc, the milk of the cow-tree, various seeds, &c.

General Summary.

Space forbids a review in detail of each class of objects that composed the collections enumerated, or anything more than a general glance at a few of them. A detailed review of the various tanning materials (other than chemical extracts) would be interesting. Each country exhibited its own kinds,—oak-barks and sumac-leaves from Europe and the United States, and willow from several European countries, while from others were many species practically unknown among us in the United States. From Brazil, besides barks and leaves, were large fruits. Both barks and leaves appeared from several countries, some of the exhibits accompanied with chemical analyses showing the percentages of tannin. From Portugal were several exhibits of grape-seeds for this use. We found but few exhibits of useful nuts, as a forest product, from trees truly wild; but of species usually planted, and often in a state of semi-cultivation, as chestnuts, filberts, and walnuts, there were several hundred exhibits, mostly from Southern Europe.

There were many small, and a few large, collections of seeds of trees and shrubs, the more important of which have been already alluded to. This class afterwards included other classes of seeds, swelling the number of exhibits to some hundreds.

From various countries and states there were exhibited manufactured articles, intended to show the native woods as well as to serve some other obvious use. These were usually articles of furniture or ornament, such as chairs, often of elaborate construction, tables, sometimes inlaid with an immense number of pieces and displaying a great variety of woods, ornamental boxes, &c. The cases in which other exhibits were displayed were also often intended to illustrate the resources of the country in woods for furniture, carving, ornament, or interiors. These articles, however, were usually not exhibited for competition, and where they were they came naturally under the judgment of Judges of other groups. There were also a few exhibits of ornamental woods collected without regard to the country of their production, and generally displayed to call attention to some class of manufactures, or to embellish some other exhibit.

II.—*Manufactured Parts of Buildings.*

Certain manufactured parts of buildings, carpentry, and mouldings, forming a part of Class 227, with some other articles manufactured of wood, were referred to this group. These exhibits were very varied in character; a portion of them are treated in another general report, and still others would require more space for any satisfactory notice than this sketch will allow. We will only refer incidentally to the Swedish school-house, the fittings up of the Norwegian section in the main building, and to certain Scandinavian and other private exhibits noticed in the reports of awards.

III.—*Timber and Lumber prepared to resist Decay and Combustion. Section 3 of Class* 600.

There were several exhibits offered in this class, which consisted essentially of a covering of some kind of paint or composition which more or less excludes the air and moisture, and would thus resist decay and retard ignition, precisely as a coating of well-sanded oil-paint will do, while the wood beneath remains essentially unchanged in character by the process. These, the Judges think, do not come within the intent of the classification by the Commissioners, who illustrate by the words, "as by injection of salts of copper and zinc," &c. Of the many processes devised to accomplish this end, as thus restricted, only two were represented in the Exhibition, so far as has come to our knowledge, and only one of these was for competition. This was by the Burnettizing process, which consists essentially in injection with chloride of zinc. The exhibit by the Eastern Burnettizing Company, Boston, Massachusetts, consisted of shingles and lumber that had been treated, and were alleged to have been used for eleven to nineteen years in positions where they were subject to various influences of decay, which they successfully resisted. Three species of wood were exhibited in specimens, such as shingles, used, according to the testimony of the exhibitors, on roofs eleven years; railroad-ties, eleven to eighteen years; and bridge-timbers, cellar-floor, and sweat-vat, twelve to nineteen years. There were other exhibits of wood treated by this process, not exhibited by the manufacturers, shown for other purposes, and excluded from competition in this group.

There were also several exhibits of woods prepared by the Bethell process, but none were shown by the manufacturers, and none so exhibited as to be eligible for award. The most considerable and interesting was exhibited by Page, Kidder, & Fletcher, of New York, manufacturers of coal-tar products. The process consists essentially in injecting the wood with one of the products of coal-tar distillation, known in England as "creasote oil"; in the United States better known as "dead oil." It is claimed that the process greatly hinders decay, and also preserves the wood from destruction by marine-worms. Many specimens were exhibited, some from English and others from American establishments, consisting of railroad-ties and other timber and lumber said to have been long used, but which were still sound; also, piles and timbers used in salt water, and still sound, contrasted with similar pieces not so treated, more or less destroyed by marine-worms. Along with these specimens were samples of the oil used, a model of the machinery used in the process, &c. We are informed that there are six establishments in the United States using this process. There were other exhibits (one in the United States Government collection) of woods treated by this process.

IV.—*Forestry; Illustrations of the Art of Planting, Managing, and Protecting Forests; Statistics. Class* 606.

For our present purpose this class can be considered in three sections, viz.:—

a. The planting, care, and administration of forests in general.

b. The planting and care of trees and shrubs producing commercial products, excluding such cultivated kinds as orchard fruits, almonds, coffee, &c., which are economically imported only as cultivated plants.

c. The literature of the subject, including maps and statistics.

a. Trees are of such slow growth and long life, and large timber requires so many years to mature, that their cultivation is not attractive to that large mass of the cultivators of the soil who must reap the rewards of their labours

year by year, or who, if their necessities are not so pressing, are still impatient for quick profits. Some of the larger timbers on exhibition were of over six hundred years' growth, and a stick of box-wood was shown which was claimed to be over nine hundred years' growth. Hence we see why it is that forestry proper is only practised on a large scale where there is Government aid or supervision, or where a considerable proportion of the land is held in large estates remaining in the possession of the same family from generation to generation. The abundance and variety of native timber originally found and still existing over much of the United States, combined with the character of our landed proprietorship, have tended to make the people careless as to future timber-supplies, and forestry as a science can hardly be said to exist in this country. The nearest approach to it is found in the endeavours to grow trees in portions of the West where the natural supply of wood is scanty.

In a private exhibit from California there was a long section of a trunk of the Australian blue-gum (*Eucalyptus globulus*) "eleven years old" and "sixty feet high." The section was eighteen inches in diameter, exclusive of bark, at the base, and thirteen inches at five feet above. This species is now extensively planted in the State.

From Iowa were specimens in boards of the wood of cultivated native and exotic forest-trees, some of them showing very rapid growth, as "silver-leaf maple, nine years old," seven inches in diameter exclusive of the bark; "ash-leaved maple, eight years old," eight inches in diameter; "chestnut, fifteen years old," nine inches; "persimmon, twenty-seven years old," nineteen inches, &c.; a considerable number of species having been thus shown.

In the Kansas collection there was also a collection of the woods, in cross-sections, of cultivated forest-trees of native and foreign species. Cottonwood "seventeen years from the seed," with a diameter of twenty inches (these diameters are of the wood exclusive of bark, and as now shrunken by drying); Scotch fir, "eleven years old," and nine inches in diameter; "maple, ten years from the seed," eleven inches; "soft-maple, eight years from the seed," six and one-half inches; "white-oak, ten years old," six inches; and so on through a considerable number of species. A few specimens from planted trees occurred in other State collections without special information of importance regarding them.

From other countries, however, the exhibits were far different. In Spain, the forests are largely under State management and control, each district having its "Forestral Engineers," who are public officers, and its "Inspection of Forests," which is a department of the Government. The official collective exhibits of this country were mainly through this department, and in the collections no distinction was made between such timbers as are self-planted and those planted by art. A similar state of facts existed in regard to the collections of Portugal and various other countries. Not unfrequently more or less complete displays of the implements and tools used in forestry were shown, as in the Portuguese and Spanish collections, and from several countries came tree-seeds in quantity of a few of the more important species.

b. Closely related to the planting of forests is the growing of semi-cultivated trees and shrubs yielding commercial products other than wood and timber, such as cork, caoutchouc, chestnuts, walnuts, filberts, carob-beans, resins, cinchona, tan barks, &c. The only exhibit of this kind from the United States which came before this group for competition was that of pecan-nuts, from Louisiana. The exhibit was from a grafted tree, or an artificially-planted stock, the exhibited product being of such great excellence as to promise profit to those who would intelligently extend its cultivation. From Southern Europe, particularly from Portugal, Spain, and Italy, the number of exhibits of nuts was very large, amounting to some hundreds. What can be done by the selection of seed for planting, choice of soil, and other treatment known to art and science, was well seen in the number of varieties of the European walnut on exhibition, where the variety is so great that, were only the extremes known, the botanist might consider them distinct species. In those countries chestnuts constitute a still more important crop, in some districts almost taking the place of bread, in others constituting an important item of

food for some millions of people, and the exhibits were varied and numerous. Even acorns and pine-nuts, as articles of human food, as well as for animals, were exhibited from several countries.

Of cork we have already spoken, as being largely the product of Spain and Portugal. These countries appear to be the great producers of this necessary article, partly because of favourable climate and soil, but more because of the existence of the systems of public forest-culture and administration. Small specimens were shown from several other countries.

Several species of *cinchona* furnish the "fever-bark," which is the raw material from which quinine and a few other similar medicinal alkaloids are extracted. Thirty-sixty species are known to science, all natives of the tropical Andes. All contain quinine, but only a small part of them are of much importance in commerce. As its use spread throughout the civilised world, and the methods for chemically extracting the drug were improved, the demand rapidly increased, and the natural supply of bark as rapidly decreased. When a demand arises for any forest-product, the native forests are soon despoiled of the trees which produce it, for no trees growing wild, and especially if they are the property of no one in particular, can withstand the reckless and improvident attacks made by those who procure the crude materials for commerce. The more valuable the product or more urgent the demand, the more sure the destruction. This has been the history of various products, and is emphatically that of the quinine-producing trees, where the raw product is the bark, a vital part of the tree. As the demand for the drug becomes more imperious and the natural supply more uncertain, the necessity for its cultivation becomes more obvious. The Netherlands claim to have been the first to produce the bark as a commercial product from trees artificially planted, in their East India colonies, and their exhibit was by far the finest of its kind in the Exhibition. According to the Netherlands Sectional Catalogue, the first cinchona trees were introduced into Java from European Botanic Gardens in 1851. In 1852 a botanist was sent by the Dutch Government to Peru, where he investigated the different species in their native localities, and collected plants and seeds of the more valuable species. Some of these were sent to Holland *viâ* Panama, and thence to the Dutch East Indies, but more were carried in 1854, by a Dutch man-of-war sailing directly from Callao to Java. From that time to this the cultivation has gone on, and in March, 1875, the several Government plantations contained more than two millions of trees, the whole under charge of the chemist and botanist, J. C. Bernelot Moens, who made the exhibit here. This exhibit consisted of herbarium specimens of the foliage, flowers, and fruit of seven species in ten varieties, with sections of their wood, bales of bark, photographs of the plantations, pulverised bark, large jars of quinine and the other alkaloids, the whole accompanied with a printed account of the history, treatment, and cultivation of the species, chemical analyses of the several kinds of bark, both as they occur wild and from the cultivated trees, with the relative amount of the several alkaloids in each, also a description of the laboratory for extracting the alkaloids for commerce, &c. We have no statistics of the commercial production.

In British India the cultivation of cinchona began, we think, about the same time, or soon after. In the Indian collection (see special Catalogue for India, Nos. 546–549) there were four small exhibits of bark, of two species, from the Neilgherry Hills, the principal seat of the industry. In the private exhibit of a chemical manufacturer was a larger quantity of bark from the same source, shown as a curiosity. A recent scientific journal states that the harvest of bark from the whole Madras Presidency for the year 1875 was 130,000 pounds. A part of this was from private plantations supplied with trees from Government nurseries.

From Jamaica the bark of three species, and the peeled trunk of a tree, were exhibited by Mr. Robert Thompson, Government botanist for that island. The cultivation was begun there by the Government in 1868, and three hundred acres are now planted. (See descriptive Catalogue of Jamaica, Nos. 229–231.)

From Cordova, Mexico, three species were exhibited by Mr. Hugo Frink. Each was shown in specimens of the bark, foliage, flowers, fruit, and sections of the trees. This exhibit was especially interesting, because it was the only

one in the Exhibition which came to our notice where the cultivated product was entirely due to private enterprise. We have no information as to its commercial success.

The only exhibit of cinchona as a wild forest-product was from Venezuela. Three species were shown, with the statement (Venezuelan special Catalogue, Nos. 161–163) that the annual export amounts to about sixty thousand pounds of the bark, most of which comes to the United States.

There were several exhibits of living rubber-producing plants, embracing a considerable number of species; but they were shown along with exhibits of rubber or other products, or as botanical specimens, and not as cultivated trees producing a commercial product. In fact, as yet, rubber, as a commercial product, is nowhere produced from cultivated trees.

c. From the United States the only forest literature exhibited and coming under our notice were several annotated Catalogues of exhibits, and they related to natural products rather than to cultivated woods. The most important was the Catalogue of the Government collection of woods, by Dr. Vasey; that of Michigan, by Professor Beal; and of West Virginia, by Mr. Maury, each of which has already been noticed when speaking of the wood-exhibits they describe. Similar to the above, but fuller in description and not accompanied by specimens of the woods themselves, was a descriptive catalogue of the *Trees and Shrubs of New Brunswick*, by Professor L. W. Bailey. From the United States were two woodland maps. The first, especially prepared for the Exhibition, was a large "map showing in five degrees of density the proportion of woodlands to farm areas of the United States, compiled from returns of the Ninth Census, by J. R. Dodge, Statistician, Department of Agriculture." This map did not profess to show the actual distribution or density of our forests, but the proportion of woodland to non-woodlands in the cultivated farms was well indicated. The second was a small printed map, forming one of the set published by Congress in Professor Walker's Statistical Atlas of the United States, prepared by Professor William H. Brewer, showing the actual distribution of woodlands in six degrees of density. It was founded partly on the returns of the Ninth Census, and partly on estimates made by many observers, official and unofficial, independently of each other. The map was accompanied by a short memoir. In the same statistical atlas, which was exhibited both as a Government and a private exhibit, and in the published report of the Ninth Census, were the statistics of lumber production and lumber manufacture in the country; but the map, memoir, and statistical tables formed only a part of much more extensive figures, and were not a separate work devoted to forest-productions.

From Mexico there was a botanical map of a part of the State of Queretaro, by Sr. Mariano Barcena, which is, so far as we have knowledge, the first botanical map of any part of Mexico. The distribution of various orders of vegetation was shown in eleven colours, the map being only forestral in so far as the special orders shown are particularly woody orders.

Several of the countries of Europe exhibited topographical maps prepared from official surveys. Some of these maps showed a wonderful amount of detail, and, as one of the features, woodlands and forests were shown wherever they occur. Such maps are forestral and statistical only in this, that they show the forest-area as one of the features to be pourtrayed on a general and topographical map, and in this sketch may be passed by. They are only noticed because it may possibly explain why some countries which were otherwise so well represented in the Exhibition by maps, had none especially devoted to forest-features or forest-products. Of the countries represented by maps and literature specially pertaining to this subject, we have the following:

From Russia was a series of ten published official maps of European Russia, showing by shadings and lines the distribution and relative densities of forests, the range and limits of six of the more important timber species, the areas of the entire forests in comparison with those of the state forests and of each with the areas of territory, the relation of forest-areas to total populations and local populations, the management and working of forests, and the mean annual revenues of the Government forests in each state. These were accompanied by statistics, and by a memoir on the forests and their products. These ten forest maps were a part of a larger series, in which were ten

other maps relating to meteorology, temperature, agricultural productions and statistics.

From Norway there were a forest map showing the economic relations in 1870, and a botanical map giving the limits of range of growth of every timber species (along with others), whether wild or cultivated.

From Spain, where the forests are under Government supervision, we had a volume of titles, with notes on contents of all the literature relating to forests which has appeared in Spanish, whether original or in translations, by Don José Jordana y Morera, Forestral Engineer. The literature is grouped into classes, and extends to eleven hundred and twenty-six titles.

From Portugal we had three maps and a chart showing the distribution of forests, the distribution and limits of the more important species, with their relation to the topography of the country, the climate, and their proximity to the sea, and the relative economic importance of forest-products in the different districts.

From the Philippine Islands we had the Catalogue memoir already spoken of, which contained information relating to the use of the various woods, statistics of production and export, and two coloured maps showing the distribution of the forests on the islands of the Archipelago.

GENERAL REPORT

ON

GROUP VIII.

COTTON, LINEN, AND OTHER FABRICS, WITH THE MACHINERY.

JUDGES.

American.

Mr. Edward Atkinson, Boston, Mass.
Mr. Hugh Waddell, Savannah, Ga.
Col. Ed. Richardson, Jackson, Miss.
Mr. A. D. Lockwood, Providence. R. I.
Mr. Chas. H. Wolff, Cincinnati, Ohio.
Col. Samuel Webber, C. E., Manchester, N. H.
Mr. Geo. O. Baker, Selma, Ala.

Foreign.

Mr. Isaac Watts (President), Great Britain.
Mr. W. W. Hulse, C.E., Great Britain.
Don Alvaro De La Gandara, Spain.
Major A. Goldy, Switzerland.
Prof, Friedrich Gustav Herrmann, Germany.
Prof. Giuseppe Dassi, Italy.

GENERAL REPORT.

COTTON, LINEN, AND OTHER FABRICS.

Class 228.—Woven Fabrics of Mineral Origin.

This class comprised woven fabrics of mineral origin. The exhibits were numerous and excellent, though in some of them there appeared room for much improvement as regards ornamentation. The wire-cloths, sieve-cloths, wire-screens, and bolting-cloths were, as a whole, highly creditable, and deserving of commendation, on account both of the taste and economy displayed in their production. The garden ornaments were graceful, and well adapted to different varieties of climate. The wire fabrics for manufacturing purposes comprised several novel improvements. Among these may be mentioned the wire fire-proof lath, serving as a base for ordinary mortar plastering, or for asbestos covering, meeting, to some extent, a much-felt want for the purpose of rendering buildings thoroughly fire-proof. The asbestos fibre and fabrics deserve special mention, as, both on account of their variety and practical uses, they surpassed anything exhibited on previous occasions. For steam-packing, steam-joints, roofing, pipe-covering, and other purposes where excessive heat or fire has to be overcome, the material appeared to have been successfully utilised. Wood covered with asbestos, moistened with water or other liquid, and hardened by exposure to the atmosphere, seems able to defy the action of fire; while, from its properties of toughness, elasticity, and non-conduction of heat, as well as on account of its cheapness, it appears likely to be of great utility. As a covering for pipes used for the transmission of water or steam, its practical value will attract increasing attention; while, as a material for the production of non-combustible writing-paper, it may prove to be of considerable advantage where the preservation of private or public documents is important. This remarkable mineral product is found extensively distributed over the world, and is obtained in quantities from Italy, Germany, Switzerland, Canada, California, Pennsylvania, Maryland, Carolina, Vermont, Maine, Virginia, Texas, and others of the United States.

Class 229.—Coarse Fabrics of Grass, Rattan, Cocoa-nut, and Bark.

The Exhibition was remarkably rich in these exhibits; and the display was in all respects most satisfactory. The various novel, economical, and useful articles of rattan deserve special notice, while the grasses and barks, in fibre and fabrics, evince considerable progress, and indicate the wonderful expansion in this direction which may yet be expected. In mattings,—Chinese, Japanese, palm-leaf, grass, and rushes; floor-cloths of rattan, cocoa-nut fibre, aloe, etc.,—it was satisfactory to observe the thorough blending of the artistic and the useful. There is, however, a vast field yet to be explored in the collection of the different varieties of these fibres, and in the employment of more of them in each fabric, as well as in the invention of machinery suitable for the purpose. This may be encouraged by the increased demand likely to arise for floor-cloth, mattings, etc., on sanitary grounds,—especially in the heated miasmatic regions of America and elsewhere.

Class 665.—Raw Cotton, Ginned, etc.

In this class there was scarcely any foreign competition, the cottons exhibited being almost entirely of American growth. Brazil, indeed, furnished, in small bales, some excellent specimens of the various descriptions produced in that empire, known as Pernambuco, Paraiba, Santos, Bahia, Maranham, and Maccio cotton. From India, two bales, of the usual size, of Dhollera, Hingunghût, Oomrawuttee, Broach, Dhawar, Bengal, and Madras cottons were exhibited, not for competition, but as an illustration of the mode in which the raw material is prepared and sent to market. From Egypt, and some other minor cotton-growing countries, small samples were furnished, which served to show their progress and capabilities; but nearly all the large commercial bales were

from the Southern States of the Union. Some remarkably fine specimens of Sea Island cotton, grown in America, the Fiji Islands, Queensland, and elsewhere, excited much admiration. A quantity of cotton was drawn from the separate bales by expert samplers; and each lot, having a number attached to it, was examined, without the possibility of any one's knowing in what district or by what planter it had been grown, in order to secure a perfectly impartial decision. When the names of the successful competitors were disclosed, it was discovered that one of them was a coloured planter. This to myself was a source of special gratification, from the fact that I had for many years been engaged, in connection with the Cotton Supply Association of England, in promoting the cultivation of cotton in the colonies and dependencies of Great Britain and throughout the world, by free labour, at the time when the manufactures of every country were almost entirely dependent upon slavery for the raw material which they required. I may also, perhaps, be permitted to state that I had the privilege of receiving, during the cotton famine in England, the first cotton (consisting of four bales) grown near Vicksburg by free coloured labour in the then slave-holding States of the Union, and I could not but rejoice to meet the coloured planter by the side of his white competitor, in amicable rivalry, and able to establish a claim to pre-eminence in this great branch of American industry.

Class 666.—Hemp, Flax, Jute, Ramie, etc.

Both in their primitive forms, and in the stages of preparation for spinning, the assortments were very complete, and the cultivated portions showed that considerable progress had been made in their improvement. This was especially observable in the different kinds of jute exhibited, of which there were several new varieties. The entire collection of these fibres was extremely interesting, and the careful examination of them justifies the conclusion that they are capable of much further application, and that they are likely to prove of great value and come into extensive use. Whether considered botanically or commercially they are deserving of attention, and may be made to answer a variety of important practical purposes. The rhea fibre, or China-grass, known by its Malay name of ramie,—the *Bœhmeria mica* of the botanist,—claims special attention, as likely to become a most valuable material for manufacturing purposes when the difficulties hitherto experienced in its preparation shall have been overcome. The information and samples obtained from China to aid the investigations of Dr. Falconer enabled him, and afterwards Sir William Hooker, to determine that rhea is the same plant as that from which Chinese grass-cloth is manufactured; and, in the London Exhibition of 1851, several specimens, in various stages of preparation, attracted attention and gave rise to subsequent experiments for utilising the fibre. These experiments have served to demonstrate that its inherent qualities entitle it to take a high position among fibres, and that it is pre-eminent for its strength and lustre in comparison with others. It has been shown to be considerably stronger than either flax or hemp, and, while the fibres are as fine as those of flax, if not finer, it has also the additional advantage of possessing, in a remarkable degree, a silky lustre. Jute, the only other fibre which can compete with it in this respect, is far inferior to it in strength and durability, as well as in its capability for bleaching and dyeing. It has been tried as a substitute for cotton, hemp, flax, wool, and silk. During the scarcity of cotton in England, cottonised rhea was spun, and the yarn woven into different fabrics, and dyed and printed. In some cases it was mixed with Egyptian, and in others with India cotton. The fabrics acquired a gloss which gave them the appearance of linen. Though the experiment was to a certain extent successful, the cost and other considerations precluded the possibility of its use as a substitute for cotton. It may, however, become a formidable rival to flax, in the finer varieties. It has also been successfully used as a substitute for longer-stapled wools; and, since the Exhibition of 1851, many attempts have been made, both in England and France, to test its suitability as a substitute for silk, or as an admixture with it, but in this respect it has a formidable rival in jute, on account of its greater cheapness. The superiority of rhea to hemp as regards strength and resistance to water may make it an advantageous substitute, and it may be possible to replace hempen cordage by lighter rhea ones. Should the prices of the raw material become reduced, and the means

of its preparation be improved, rhea can scarcely fail to take a high place among fibres, and to come into more extensive use. Indeed, there hardly exists a fibre which, on account of its own inherent properties, can be applied to so many different purposes. It is capable of entering largely into textile manufactures, and, as compared with flax,—which possesses the most extended range of applications, from the roughest canvas and cordage to the finest lace,—rhea has a range even greater still, owing partly to the superlative degree in which it is endowed with the qualities of fineness, strength, and lustre, seldom found in the same perfection in any single fibre, and partly to the singular position which it holds between the usual vegetable and the animal fibres. Although a vegetable fibre, its hairiness assimilates it to wool, and its gloss and fineness to silk. Thus it appears that rhea is capable of as wide a range of applications as hemp, to which it is superior in almost every respect, and as flax also, with the exception perhaps of its use for body linen, while it is capable of certain other uses for which only the animal fibres, wool and silk, have hitherto been employed. The cost of the raw material alone may be said to prevent its extensive introduction into manufactures. Any slight technical difficulties experienced in spinning and weaving which may remain would speedily be overcome if the price were reduced so as to make its use remunerative. The cultivation of the rhea plant on a large scale has been encouraged by the British Government in India; and prizes of 5,000*l.* and 2,000*l.* each were offered for the production of machinery to facilitate its preparation for the market, in order to promote its more extensive use for manufacturing purposes. An extended cultivation of this valuable fibre in America will probably effect an increasing demand for its employment in manufactures.

Classes 230, 231, 232.—Cotton Yarns and Fabrics.

These classes comprise exhibits which show in a striking manner the wonderful progress made by the cotton industry in the United States, and the remarkable degree of perfection which has already been attained, but they afford only scanty opportunities for comparison with the manufactures of other countries. The comparatively meagre collections sent by England and other European nations is chiefly attributable to the excessive protective tariffs which still find favour in America, and exclude foreign manufactures from her markets. Those who were thus precluded from the possibilities of trade found but little inducement to incur the trouble and expense of sending their goods to Philadelphia, and they therefore became conspicuous chiefly by their absence. On this account it was a subject of great regret, in which almost every European representative shared, that no complete comparison could be made, and that one of the most valuable purposes of an International Exhibition was thereby frustrated. But while American textile manufacturers had the field almost entirely to themselves, the small collections supplied by their foreign competitors were sufficient to show that they have nothing to fear whenever they can meet on equal terms, with a fair field and no favour. The general excellence and, in some cases, the superiority of the display made by England and her colonies was fully admitted, and the fabrics sent by the various manufacturing countries of the Continent of Europe were generally distinguished by qualities which placed them upon a par with the best productions of America. Indeed, the praises bestowed upon the few goods exhibited by foreign manufacturers made it a matter of regret that the number had not been largely increased. Canada made a remarkable display,—one which excited universal admiration, and which, as regards articles of clothing and textile fabrics of all kinds, was fully equal to any in the Exhibition. The American display of textile manufactures was extensive, varied, and important in every respect. The collection of fabrics produced in the numerous mills of the New England States, New York, New Jersey, and other parts of the Union, was as complete as it well could be, and afforded a striking proof of their capability to compete with the manufacturers of other countries, if it were not for the policy which, to a great extent, excludes them from the general markets of the world. The goods exhibited were, for the most part, pure, even, firm, and well manufactured. The dyed cotton fabrics were pre-eminent for brightness, colouring, and durability. The bleaching, dyeing, and finishing of the various

grades and styles of cotton cloth evinced much superiority, which is probably, in some degree, attributable to the abundance of excellent water which exists throughout the States. The cotton prints and calicoes, and the coloured and fancy goods exhibited both by American manufacturers and their foreign competitors were so nearly upon an equality that no one could lay claim to any marked degree of superiority. Some bleached shirtings from England attracted attention on account of their special fineness and even texture, combined with softness and purity, while the collective exhibits from the Gladbach district, Würtemberg, and Elberfeld, in Germany, were of pre-eminent excellence. The striking effects produced by the Jacquard loom are deserving of high commendation. The beauty of the designs and the embroidery in handkerchiefs, scarfs, &c., were deservedly much admired. The whole of these classes were conspicuous for exquisite workmanship, elegance of design, and harmonious blending of colours. On the part of every country much versatility of taste and skill was displayed. There was nothing gaudy, or that could offend the most fastidious or critical observer. The spirited and amicable contest for supremacy into which all nations more or less entered in the Centennial Exhibition, proves the remarkable progress which has been made in the course of the past century, and affords a powerful stimulus to further enterprise and exertion.

Class 233.—Linen and other Vegetable Fabrics.

The linen fabrics constituting this class were varied and extensive, and were remarkable for their superior fineness and quality. The Irish manufacturers may justly be said to have taken the lead; those of Scotland were but little behind, while Dresden, Würtemberg, Belgium, the Netherlands, Austria, Italy, Sweden, and Norway all presented a very creditable display. The American exhibitors in this class were not numerous, nor did they offer so great a variety as their foreign competitors. These fabrics were of general excellence and utility, and some were remarkable for the superior taste manifested in the colouring. Some of the printed lawns, brocades, and embroidered linens displayed much novelty and elegance of design. The damasks of Dresden and the embroidered linens in the collective exhibit of Würtemberg were deserving of special mention. If pre-eminence may be claimed by the manufacturers of Ireland, it is only in such a degree as to extinguish envy and excite emulation. All the competing countries in this class are entitled to commendation, and may be congratulated on the progress already made, and the promise thus afforded of still further excellence.

Classes 234, 521, 523, 524.

On these classes the following statement has been furnished by Mr. William W. Hulse, a member of the group:

"The Chairman of Group VIII. has desired me to send a comparative report on the machinery, as an addendum to his own report. But, really, it is not practicable to form a judgment based on comparison, for lack of means, there being in no instance a complete set of textile machinery exhibited from any nation. The only exhibit which approached completeness was in the United States department, and it was not worked, but kept idle. If I might venture on giving some opinions which I formed, of an abstract character, I would say that, as regards extent of invention and ingenuity of detail, the United States were far ahead, for there was scarcely an exhibitor who had not some novel features to claim. For consummate invention and arrangement of mechanism—based, no doubt, on an older experience—the palm was, in my judgment, earned for Great Britain. I attributed the extent of ingenuity and invention manifested everywhere in the machinery department of the United States to the fostering, stimulating, and admirable patent-law system. As regards quality of construction, utility, and fitness for the purpose intended, I formed the opinion that the cotton-gin and the calico-printing machinery, and the machinery and tie-in warps from Yorkshire, were the most solid and best examples. The cotton-spool machinery of Conant; the calico-dyeing machinery by Butterworth; spinning and weaving machinery by Draper, Lord, & Co., Kitson, Lyall, Thomas, Crompton, Knowles, and others; and the tentering machinery by Palmer—all of the United States,—followed very closely upon the best examples from Great Britain.

"The other class upon which I had to form a judgment, in connection with my co-Judges in textile machinery, was that of oil-cloths. In this class I had no hesitation in assigning the first place to the United States, for great variety, beauty of design, richness of colours, and quality of texture in oil floor-cloths, table-cloths, carriage-cloths, and fancy cloths for upholstery; the best exhibit, in my opinion, being that of Messrs. Potter, Sons, and Co. For design and finish, durability of fabric and colours, and flexibility of oil floor-cloths of extraordinary size and area, the best example in the Exhibition (being fifteen yards long by eight yards wide, in one web) was exhibited by Messrs. Nairn & Co., of Scotland, Great Britain. In other floor-cloths, the Boulinikon, from England, and the American Linoleum floor-cloth were both excellent in quality, design, colours, durability, and strength, and for warmth to the feet were unsurpassed. It has been my misfortune, in making this report, not to have the assistance at hand of my excellent co-Judges, Messrs. Webber and Lockwood and Professor Hermann, of Germany, on machinery, and Messrs. Waddell and Baker on floor-cloths, &c. I should be very sorry if my opinion, thus expressed, should in any way differ from theirs; but, so far as I could gather at the time, I am inclined to think it does not."

American Cotton and Cotton Manufactures.

By Edward Atkinson.

The report of the Chairman of Group VIII. gives a sufficient statement of the details of the results reached by the Judges of that group; but it may, perhaps, be well for the Secretary to make a more general report upon one of the principal subjects of which the Judges were called upon to take cognizance, to wit, the cotton production and cotton manufacture of the United States.

The commanding position of the United States in respect to the production of cotton has long been admitted; but it seems probable that even few of the manufacturers themselves have been fully aware of the strong position in which the cotton manufacture of the United States now stands in relation to other countries.

The subject of the production of cotton opens so wide a field that it is hard to know where to begin or end. There is no other product which has had so potent an influence upon the history and institutions of the land, and perhaps no other on which its future material welfare may more depend. When the Spaniards first entered Mexico, the natives were found to be clothed in cotton, and the art of weaving and dyeing had been carried to a high state of perfection for that time among them. Then, as now, the best and most prolific varieties of the cotton-plant existed there, and the plant is doubtless indigenous to Mexico.

In the United States, a century ago, it was scarcely known as an important production, and not until the invention of the saw-gin by Eli Whitney, in 1792, did it become so. To-day the United States furnish nearly three-fourths the quantity consumed in their own limits, in Canada, and in Europe combined. There are no data by which the quantity produced and consumed elsewhere can be accurately determined. It may therefore be a matter of interest to state and record, in this report, the work which we have accomplished, and to forecast the work we may yet have to do.

Among the three fibres—wool, flax, and cotton—which constitute the principal materials for clothing, cotton is the most important; because it is ready for treatment by machinery as soon as it is gathered, because its conversion into cloth is least costly, and because its use for clothing is most conducive to health, in respect to the largest portion of the population of the world.

In the cotton-factories of Europe and the United States there are a little over sixty-eight million spindles, worked by about one million men, women, and children. In the operation of these spindles a little more than six million bales of cotton, of the average weight of American bales, are annually converted into ten thousand million yards of cloth, averaging one yard wide and four yards to the pound, or ten pounds to a piece of forty yards, or into the equivalent of such cloth in other fabrics. This quantity of cloth would furnish five hundred million persons twenty yards each, annually. Of the six million bales of cotton, the United States now furnish about four and a half millions in each year; and our proportion is, year by year, increasing. The

last eight crops raised by the labour of freemen exceed the last eight crops raised, before our civil war, mainly by the labour of slaves, in the number of more than fifteen hundred thousand bales. If, then, it be a service to men to provide for them the largest quantity of the material that best serves their need for clothing, in this one respect our rank is assured. Then let us mark the extent to which we have yet trenched upon our resources. In this production less than two per cent. of the area of the cotton States is yet used. What we may yet accomplish may be better realised by considering the condition of a single State. We will select Texas, as being the State now making the most rapid progress in population, production, and wealth. Few persons can realise the facts in regard to this great State, except by comparison. In area it exceeds the German Empire by about sixty thousand square miles. It has the capacity to produce almost all the products of the temperate zone. It is underlaid with coal. But, in respect to cotton, on less than one-half of one per cent. of its area it last year produced one-half of all the cotton consumed in the United States; and four per cent. of its area would be capable of producing all the cotton now consumed in Europe and the United States—over six million bales.

Under what conditions is this work now accomplished, or yet to be done? No longer by the forced labour of the slave upon the plantation, but by the labour of freemen, and mostly of freeholders on the farm. In most of the States where it is now grown cotton constitutes the saleable or money crop of the farmer, who, in other respects, is becoming entirely independent as to his subsistence, raising food and meat to a greater extent than ever before. The Southern farmer still finds in cotton the means wherewith to furnish himself with money for other purchases. Cotton, therefore, being more and more the surplus crop or profit of the farmer, as distinguished from the planter, it becomes more difficult to determine its cost, its annual quantity until each year's crop has been delivered, or the prices at which its production will be checked. In answer to a very extended inquiry lately made by the writer, he has received estimates of the cost of production, ranging from six to fifteen cents per pound; the latter cost, however, having been given by one who, on twelve hundred acres of land, made only four bales of cotton the previous year. The general range of the estimates of cost were from six to ten cents. One answer to the question of cost was most significant. One said, "I have a nephew, twenty years of age, who, without the least detriment to his schooling, and working Saturdays, produced four bales of cotton." It may be asked, what did this lad's cotton cost to produce?

According to these returns, this Centennial year is also marked by greater improvements than ever before in the selection of seed, in the improvement of tools, in the use of fertilizers, and in the average crop per acre; positive evidence having been given of the production of two thousand five hundred pounds of lint or clean cotton on a single measured acre in Georgia. It was not claimed that this had been, or could be, profitable; but it is significant of the experiments that are being tried in many places. The average estimates of profitable work range from four hundred to one thousand pounds of lint, or clean cotton, per acre, according to the quality of the soil and the kind of work done.

The last ten years have also witnessed the conversion of the seed of the cotton-plant into many useful articles but little known before.

The future production of cotton in the United States, and the time within which our staple will take the place of all inferior grades is, therefore, only a question of numbers and intelligence. In respect to intelligence, it is not to be questioned that the planter of old time had far more skill than many of the farmers of the present time; but the system of labour to which that skill was applied imposed conditions that could not be surmounted, and enforced the use of tools and methods unfit for the purpose. These methods may have assured prosperity to the few at the cost of the many; but it was the high price, and not the low price of cotton, that limited the extension of the crop. Twenty years since, every bale that could be made by the force then upon the cotton-field was needed; and, under the steadily advancing price, the cost of opening new fields as steadily increased, until, in 1860, it cost fifty per cent. more to buy and stock a cotton plantation to raise the cotton for a given factory than it did to build the mill and fill it with machinery. All this has changed; and, in the five years last passed, more than a million persons have

migrated to the fertile lands of Texas; and the independent freeholder will only be prevented from making more and more cotton each year by the low price, and not by the high price, it may bring. That no such check is very near may presently be made apparent.

In regard to the exhibit of raw cotton, the exhibition was marked by a collection of commercial bales of every variety of cotton customarily sold in Europe, collected by Messrs. Claghorn, Herring, & Co., of Philadelphia, and said to have been the best collection ever made. It has been sold to the Dutch authorities, and is to constitute a part of an international exhibition of the products of the soil about to be opened in Amsterdam.

The exhibit of American cotton was limited in quantity, but was of the finest quality. Every bale was of the highest grade; but, as it appeared to be the desire of the contributors that the selection should be a very rigid one, it was made by rejecting one bale after another, until there remained but three, among which the Judges could make no discrimination, and for which they made three awards. When the key was opened that disclosed the name and status of the contributors, it was found, to the equal satisfaction of all the Judges, whether from the North or South or from abroad, that one of the diplomas had been gained by a freedman,—one whose farm, formerly known as the Joe Davis Plantation, in Mississippi, now proves that the production of cotton no longer depends on slavery for its abundance or its quality; while another was gained by a Vermont farmer who moved to Louisiana since the war ended.

In one respect, great improvement is needed where little has yet been made. The separation of the lint from the seed is the process that should be most fitly accomplished, but which is now most rudely done. The best saw-gin, of the usual construction, unless most carefully attended, tears, breaks, doubles, and otherwise injures the staple, and but a small proportion of the cotton now made is delivered to the spinner in the best condition. Two new cotton-gins were exhibited at Philadelphia, which promise excellent results,—the roller-gin, made by Messrs. Platt Bros. & Co., of England, and the needle-point-gin, made by the Messrs. Remington, of Ilion, New York. If these machines can be made to produce quantity in ratio to the quality of the staple which they deliver, their wide introduction cannot be long delayed.

The method of packing, covering, and handling cotton in the United States is now unfit in the extreme; and, as the competition becomes greater with declining prices, it is to be hoped and expected that better methods will be adopted. At present, it is alleged that it is not profitable to attempt better methods; but the time cannot be far distant when the bale of cotton will be as carefully prepared and protected as the bale of cotton fabrics.

In respect to the supply of cotton fabrics, this country fills as yet but a subordinate position, except as to its own inhabitants. Its relation to other countries will appear from the following table, taken mainly from the annual statement of 1875-76 of Messrs. Ellison & Co., of Liverpool:

Spindles per 1,000 of Population.	Countries.	Spindles.	Cotton per Spindle.	Estimated Amount of Consumption.
218	United States	9,600,000	63 lbs.	600,000,000
1,180	Great Britain	39,000,000	33½ "	1,297,000,000
135	France	5,000,000	42 "	
108	Germany	4,650,000	55 "	
31	Russia and Poland	2,500,000	60 "	
675	Switzerland	1,850,000	25 "	
103	Spain	1,750,000	46 "	1,009,000,000
40	Austria	1,580,000	67 "	
148	Belgium	800,000	50 "	
29	Italy	800,000	56 "	
48	Norway and Sweden	300,000	65 "	
57	Holland	230,000	60 "	
		68,060,000		2,906,000,000

Spindles, 68,060,000; pounds, 2,906,000,000; equal to a little more than six million bales of cotton of the average weight of American bales.

From this table it appears that the United States have a little more than fourteen per cent. of the spindles, and consume a little more than twenty per cent. of the cotton. About ninety-three per cent. of the production of the spindles of the United States is used at home, and about seven per cent is now exported. On the other hand, only fifteen per cent. of the production of cotton fabrics of Great Britain is used at home, and eighty-five per cent. is exported. As to the other countries named, it is probable that only two—Switzerland and Belgium—produce more cotton fabrics than they consume; the rest import more than they export.

It thus appears that the world is served to a far greater extent by Great Britain than by the United States in the matter of cotton manufactures. Yet, without trenching upon her proportion, the open field is yet vast. If we deduct the consumption of cotton fabrics of the people of the United States, the quantity of cotton consumed by the nations named in the table would furnish four hundred millions of people with twenty yards each of an average fabric thirty-six inches wide and four yards to the pound, or five pounds of the equivalent of such fabric in other varieties. It should be remembered that the clothing of the nations outside of Europe itself, which are thus supplied with five pounds, or twenty yards per head, mainly consists of cotton. How small this quantity is will appear by comparison with the use of cotton in the United States, where clothing mainly consists of other fabrics. Our consumption is of heavier fabrics, on the average; but, for the purpose of comparison, may be stated at twelve to thirteen pounds per head.

A further analysis will make it very clear that the demand for cotton fabrics may be almost indefinitely extended. For the purpose of this analysis, the case will be stated in round numbers, omitting small fractions.

The manufacture of cotton in the United States is equal to a little over thirteen pounds per head of the population, of which a little less than one pound is exported, leaving for home consumption twelve pounds *per capita*.

The cotton manufactures of Great Britain retained for home consumption, according to the annual statement compiled from the tables of the Board of Trade, are equal to only six pounds of cotton per head; but all the goods exported are much more loaded with sizing than those retained for home use. It is probable that a larger proportion of pure cotton is retained than is indicated by the tables.

The consumption of cotton in the countries on the Continent of Europe named in the preceding table is equal to about three and a quarter pounds per head, including the population of Russia, or four and one-third pounds per head, excluding Russia. But the Continent of Europe takes from Great Britain one-fourth of all her exports, equal to one pound per head additional; making a consumption of about four and a quarter pounds per head, including Russia, or five and one-fourth pounds per head, excluding Russia.

The other three-fourths of the exports from Great Britain form, or are substantially equal to, the whole supply of cotton goods, made by European machinery, now consumed in Asia, Africa, South America, Mexico, Central America, and Australia,—continents and countries said to contain from eight hundred millions to one billion population.

We have seen that the United States consume twelve pounds per head; Great Britain, six pounds per head, and probably more; Europe, exclusive of Russia, about five and one-fourth pounds per head; and these countries use cotton only as subsidiary to other fabrics, while the continents yet remaining to be considered use cotton more than any other fabric. What is their supply?

The consumption of cotton on the spindles of Great Britain is, in pounds		1,297,000,000
Less for home use	197,000,000	
Less export to continent of Europe, about	300,000,000	497,000,000
Exported to other countries from Great Britain		800,000,000
Exported to other countries from United States		40,000,000

At the rate of five pounds per head, or twenty yards of light sheeting thirty-six inches wide, or fifteen yards of drilling at thirty inches wide, for the full

dress of each person, supplied for one year, this quantity of cotton would furnish only one hundred and sixty-eight million people, or only seventeen per cent. of the population of the continents and countries named. On the average, the export of cotton fabrics from Europe and the United States to Asia, Africa, South and Central America, Mexico, and Australia is less than one pound of cotton per head of population. It follows that only one-fifth part of the population of these continents or countries is yet supplied with an average quantity of machine-made cotton fabrics required for a moderate annual consumption.

Cotton fabrics constitute the largest single item of the exports of Great Britain, and the increase of this export is no longer a question of the first cost of making the cloth. The fabric made upon modern machinery will inevitably displace the hand-spun and hand-woven fabric of Asia and Africa, if it can be placed alongside at a low cost for transportation. In this may we not find one of the lessons yet to be learned by us? May it not be our policy to promote the carrying of our goods to distant lands, by the repeal of all acts restricting navigation, and the exemption of ships from local and national taxation?

The paramount advantage of Great Britain over the United States in the export of cotton fabrics may not be in the cost of manufacture, in rate of interest, in superior skill, or other advantage affecting the first cost. Our advantage in proximity to the cotton-field of the South, the wheat-field of the West, and the pastures of the South-west, may more than counterbalance any disparity, if any exists, in these respects; but, in her vast merchant marine, unrestricted by statute, exempted from taxation, and promoted only by fair payments for service rendered in carrying mails, and in her thoroughly organised and permanent consular service, Great Britain possesses advantages over us which can never be surmounted except by adopting the same course which has given her this present supremacy.

Leaving to our competitors the share in the supply of the world's need of cotton goods which they have already secured, there yet remain, outside of Europe and the United States,—in Asia, Africa, and South America,—from four to eight hundred million people whose clothing consists mainly of cotton cloth. It must be spun and woven by the slow process of hand-work. Can we obtain our share in this unworked field? Four hundred million persons, at five pounds per head, would require from our Southern States four million additional bales of cotton, and would call for forty millions more cotton spindles in Europe or America to work them up. Who will raise this cotton, and where shall these spindles be constructed?

The empire of China is said to contain about four hundred million people, who are mainly clothed in cotton. The entire export of cotton cloth from England and the United States would supply only twenty-five to thirty millions with five pounds, or twenty yards each, if the whole supply was used for clothing. A large part of the American goods are used for the boat-sails and awnings of the immense river population, and not for clothing.

It thus appears that the cotton fabrics made upon the spindles of Europe and the United States have as yet been substituted for only a small portion of the hand-made goods of Asia and Africa, and have as yet served but a small proportion of the probable demand of South and Central America, the West Indies, and Australia.

That this demand will vastly increase with the low prices of cotton and the constantly decreasing cost of manufacturing, cannot be doubted. Hence the South has little need to fear the want of a market for all the cotton she can produce for many years to come,—nor can it be doubted that the North will contest with England the privilege of serving the increasing need of other nations. It may, therefore, be permitted the Secretary of Group VIII. to consider, from the American stand-point, the conditions under which we enter into friendly rivalry with Great Britain in this branch of industry. It is assumed that the principal seat of cotton-spinning in the United States will, for many years, remain in New England, because her more dense population and the training of the people in the necessary arts assure it.

In respect to cotton, we are nearer the cotton-field, and therefore have an advantage over Great Britain. In regard to power, our water-power has doubtless been an advantage, but with the improvements in the use of steam that advantage may be disappearing. But in regard to the use of steam, the cost of

fuel is steadily advancing in Europe and declining here. In the food of the operatives, we have the advantage. In the cost of iron, steel, and copper, we are at least even. In leather, lumber, oil, and starch, we have an advantage. On the whole, our advantages are such that, so far as the rates of wages affect the cost of production, we can afford to pay higher wages, and yet produce cotton cloth at a lower cost. The quality of our goods may not here be treated in comparison with those of other nations, but reference may be had to the report of the chairman of Group VIII., Mr. Isaac Watts, of Manchester, England, upon that point. In only one respect has our principal competitor, England, a great advantage over us, and that is in her better system of raising the municipal revenues and in the absence of restrictions upon commerce,—machinery and ships being exempt from taxation.

Thus far we have treated the question in its larger elements. Let us now consider it in its least terms, and witness what marks the progress of the century just ended.

I have assumed a yard-wide fabric, of rather poor quality, as the unit of manufacture. It would not represent the average quality called for in our own land, but would be a fair example of the average fabric exported from Europe. If made honestly, and not loaded with other substances than cotton, its cost in this country or in Great Britain, with cotton at its present price of twelve and a half cents a pound, would be not far from six cents a square yard; and the margin between the good mill and the poor one, or between one country and another, would not exceed half a cent per square yard. Commerce now depends on the smallest fractions.

Cotton fabrics are gauged by the number of the yarn of which they are made, and the number means the number of skeins of eight hundred and forty yards each contained in one pound avoirdupois. We may omit all consideration of numbers of yarn coarser than No 13, or finer than No. 40, as the greater part of the cotton manufacture of Europe and America lies within these limits. A yard of No. 13 yarn weighs six hundred and forty-one thousandths of a grain; of No. 40, two hundred and eight thousandths of a grain. The question of supremacy in the variety and cost of fabrics between Europe and America, therefore, lies within the limit of less than half a grain on the yard of the yarn that must first be spun and then woven. As to the cost, the competition is chiefly confined to plain or twilled fabrics and printed goods. In the cost of manufacture, the competition on coarse goods is within the limit of half a cent a yard, and on fine goods within a cent or a cent and a quarter a yard; in printing common calicoes, within the limit of half a cent a yard. These small fractions represent the maximum of difference in the cost of labour and supplies in a well or ill-managed mill, or between this country and Great Britain. It is not intended to admit that there is even so great, or any difference, only that these figures represent the greatest difference ever alleged. On the other hand, as we have said, a part, or the whole even, of the difference in cost of labour and supplies, if it exists, would be offset by our proximity to the cotton-field.

A marked feature in this branch of industry is in the few persons employed. In the United States the whole number of operatives in all the cotton-factories, bleacheries, and print-works does not exceed one hundred and fifty to two hundred thousand. A hundred years ago the slow and arduous labour of almost every woman was needed, in order to clothe her family, to be applied to the single spindle, now only seen upon the spinning-wheel that forms one of the curious ornaments of the parlours of those who are fond of old relics. This single spindle gave scanty material for the hand-loom, as slowly operated by some other member of the family or by a neighbour. Now, one woman clothes more than a thousand others, and in many ways lives herself more fitly and comfortably.

Textile Machinery.

By Samuel Webber.

It is somewhat difficult to make any report on the textile machinery of the Exhibition, applicable to flax and cotton, which shall attempt any international comparison, from the fact that Great Britain was the only country, except the United States, which made any attempt at an exhibition of such machinery,

and her collection was so small and so different in character from the American exhibit that no comparison can be drawn.

Commencing with the British division, the first object of note was the roller-gin, for long-stapled cotton, as modified from the McCarthy patent by Messrs. Platt, of Oldham, and now adapted to the green-seed cotton, our common variety, which was a very well-built and smoothly-working machine, doing a moderate amount of work, without injury to the staple.

The card, drawing-frame, and intermediate roving-frame of Messrs. Howard and Bullough, of Accrington, contained the only really new principle in this department, in the application of electricity to the "stop-motion," rendering it almost instantaneous, and of great value to the roving-frame, from the fact that "singles," technically so called, caused by the breaking of one of the rovings at the rollers, are almost entirely obviated.

The calico-printing machine and engravers' milling machine, from Gadd, of Manchester, were beautiful specimens of strong, simple workmanship, well adapted to their intended purpose.

The warp-tying machine of Messrs. Greenwood and Batley, of Yorkshire, was very ingenious, but at the same time necessarily complicated; and it remains to be proved whether its economical advantages and practical utility are equal to the ingenuity displayed.

The exhibits of flax and jute machinery, from Messrs. Fairbairn and Co., and Lawson and Sons, of Leeds, were fair samples of staple English machinery, massive and strong, well adapted to their purpose, but possessing no particular novelty of invention.

The American department was more particularly marked by various novelties than the British, though sadly deficient as a whole in completeness, there being no complete set of cotton machinery exhibited, although many of the separate machines were there from different makers.

There were several gins for short-staple cotton, exhibited among agricultural implements, all seeming to be well made, and capable of performing a large amount of work, and doing it well.

The cotton-opener of Kitson, of Lowell, Massachusetts, was a departure from the standard practice of late years, in the addition of a raked cylinder or "rake," to tear open the hard mats of cotton from the bale before subjecting them to the blows of the beater, thus rendering the beater more effective in removing the seeds and dirt, and at the same time saving power, and preventing injury to the staple.

The underflat card of Messrs. Foss and Pevey, of Lowell, was another decided novelty, aiming to do the work of double carding on a single machine, thus saving half the floor space in the room, and one-third of the power used by the double system. The machine promises well, and is being thoroughly tried, practically, in some of the mills of Lowell and other places.

The system of cotton machinery (unfortunately not in operation) shown by the Saco (Maine) Water-Power Machine-Shop approached more nearly to completeness than any other exhibit of the kind,—containining drawing-frame, slubber, intermediate, and fine roving-frames, and a self-acting mule of the "Parr-Curtis" pattern. For accuracy of workmanship, proportion of parts, excellence of finish, and practical utility it left nothing to be desired, and contained also various ingenious improvements. It may be considered, as a whole, the best exhibit of textile machinery from a mechanical point of view.

A set of roving-frames, slubber, intermediate, and fine, was also exhibited, in operation, by the Providence (Rhode Island) Machine Company, and fully maintained the reputation of its makers for ease and accuracy of operation, and economy of power at a high speed.

The combined "fly-frame" and "speeder" of Messrs. Mayer and Chatterton, built by Fales, Jenks, and Co., of Pawtucket, Rhode Island, was another noticeable exhibit, showing great ingenuity of combination, and possessing the most valuable points of the original machines from which it was derived.

Light and ingenious steel "speeder-flyers" of a new form, possessing great strength, as well as lightness, were exhibited by I. V. Smith, of Manchester, New Hampshire. These have given great satisfaction in mills were they have been tested.

Messrs Eaton and Ayer, of Nashua, New Hampshire, exhibited a large variety of spools, bobbins, and shuttles, with several ingenious and useful improvements.

Messrs. George Draper & Sons, of Hopedale, Massachusetts, contributed their double-adjustable spinning-rings and loom-temples from the Dutcher Temple Company; a ring spinning-frame, with the Sawyer spindle; a twister, with a spindle on the same principle; a spooler, with the "Wade" bobbin-holder; and a warper, with a combination of stop-motions. Their rings and temples are well known in the American cotton-mills, the Messrs. Draper having supplied nearly if not quite all the temples used in the United States for many years; and the Sawyer spindle, which recent trials have shown to be capable of producing more yarn in the same time than the ordinary form of ring-spindle, with a saving in addition of the power consumed, may be safely classed as an invention of great merit and utility. The Wade bobbin-holder is also coming rapidly into use, and giving entire satisfaction wherever introduced. The warper is being practically tested in various places. As a whole, the exhibit of Messrs. Draper shows a great number of novelties of invention.

The Lewiston Machine-Shop, of Lewiston, Maine, exhibited a warper of excellent construction, thorough finish, and skilful arrangement, which is in use, and highly commended, in a large number of the best mills in the United States. They also showed several looms of the Thomas patent, weaving a variety of fabrics, and a very superior loom making seamless bags. These machines may all be highly commended for adaptability to purpose and excellence of construction.

The looms of Crompton, Knowles, and Wood were all worthy of notice. The original and well-known Crompton loom has been modified and improved from time to time by successive inventions until it covers a wide range of figured or fancy-woven fabrics, and is a thoroughly well-built, trustworthy, and adaptable machine.

The Lyall Positive-Motion Loom is a comparatively new and decidedly valuable invention, of great scope and usefulness, as was shown by the two looms, side by side, one weaving wide jute canvas for floor oil-cloths, and the other, with the application of the Jacquard harness motion, producing eight corsets at once, from as many continuous warps. Besides these, other looms of the same principle were weaving sheetings and seamless bags. Taken as a whole this collection was one of the remarkable features of the Exhibition.

Messrs. Butterworth, of Philadelphia, exhibited well-made and ingenious drying machinery for bleached, dyed, or printed fabrics.

Messrs. Palmer and Kendall, of Middletown, Connecticut, showed a drying and tentering machine for such fabrics as ginghams, muslins, mosquito-nettings, &c., which require to have the weft threads held firmly and squarely at right angles to the warp while being finished. This machine was very ingenious and well made, and is deserving of notice.

The twine and thread twisting machines exhibited by Avery, of Worcester, Massachusetts, are also worthy of notice; the invention is an English one.

A very high rank in the scale of mechanical ingenuity must be accorded to the spool-winding and ticketing machines, both automatic, exhibited by the Willimantic Company. While the original conception of these machines is undoubtedly due to Hezekiah Conant, who does not appear as an exhibitor, the experiments were made and the machines perfected in the shops and at the expense of the Willimantic Company, who hold the patents, and they were properly exhibited by them. Duplicates of the same machines were shown in the British section, in the exhibit of Messrs. J. and P. Coats; but as it was clearly shown to the judges that the machines were built in America, and had never been out of the country, they were precluded from taking any notice of them, although Mr. Conant, the originator of them, formerly in the employment of the Willimantic Company, is now connected with the Messrs. Coats, in the management of the Conant Thread Company, at Pawtucket, Rhode Island, from which place the machines were sent. The Willimantic Company also exhibited a ring spinning-frame in operation on No. 160 yarn, at a speed of seven thousand five hundred revolutions of the spindle per minute. This frame was built by the Lowell Machine-Shop, and was filled, on one side, by spindles of the Sawyer patent, and on the other by a spindle which was a combination of the Sawyer and the Pearl. It has not been deemed practicable heretofore to spin such fine numbers on any machine but the mule. Specimens of their product in all its stages were exhibited; and the excellence of their thread is a sufficient comment on the perfection of their processes and machinery.

Another automatic spool-winding machine, which attracted much attention, was exhibited by the Clark Thread Company, of Newark, New Jersey, but it was an English invention, dating back some ten years.

The Messrs. Hope, of Providence, Rhode Island, exhibited pantograph engraving machines for calico-printers, of excellent construction. These machines are well known and in general use in the print-works in the United States.

This completes the list of the more noticeable machines exhibited. The rapid growth and great extension of the cotton manufacture in the United States, now employing nearly ten million spindles, combined with the high cost of manual labour, has caused a vast amount of ingenuity to be devoted to the construction of labour-saving machinery, and we regret that a more full exhibit of our cotton machinery was not made, and one or more complete systems shown in operation.

The same causes, combined with the former high prices of the metals used in construction, to a great extent, have led to the adoption of lighter forms of machines than are generally used in England, and the English judges were at first disposed to find a want of strength in machines which the Americans have found to be amply sufficient for their purpose.

The improvements made in cotton spinning in the United States were well illustrated by a comparison of the old water-twist frame, built by Samuel Slater, after Arkwright's original model, and exhibited by the Providence Machine Company, with the "Sawyer-spindle" ring frame, shown by the Messrs. Draper, or the Lowell Machine Shop frame of the Willimantic Company.

Linens.

By Samuel Webber.

The cultivation and fabrication of flax are among the oldest industries of which we have any record; and the mummy-cloths of Egypt, and the various references to fine linen in the Hebrew Scriptures, bear evidence to the very great antiquity of this manufacture.

Nearly all the countries of Europe sent linens, in some form or another, to the Centennial Exhibition, while, owing to the national interest in and extensive use of cotton, the United States made but a very meagre display, and that partially manufactured from imported flax.

By far the largest and best proportion of the flax fabrics came from Great Britain, and the collection shown by Messrs. John S. Brown and Sons, of Belfast, Ireland, may be considered as, on the whole, the leading exhibit, consisting of table linen, diapers, sheetings, shirtings, handkerchiefs, lawns, and yarns of great fineness and evenness, and of especial beauty of design and skill in weaving in the damask table-linen.

With a less full assortment, but of almost the same class, Messrs. Richardson, Sons, and Owden, of Belfast, presented equally beautiful table damask and fronting linen, and handkerchiefs of great beauty and smoothness, as well as lawns and holland. In quality there was little choice between the two.

Messrs. Henry Matier and Co., of Belfast, exhibited embroidered handkerchiefs and cuffs and collars, which were greatly admired for the fineness of the fabric and the exquisite beauty of the embroidery, together with bleached and printed linens.

Robert McBride and Co., of Belfast, showed bleached and printed linen lawns and linen and cotton fabrics of great excellence. It would occupy too much space to call attention to the merits of every exhibitor in the British department. We can simply say that all were excellent. Messrs. Fenton, Connor, and Co., of Belfast; Dicksons, Ferguson, and Co., and the York Street Flax-Spinning Company, of the same place; and the Greenmount Spinning Company, all made large and superior exhibits.

Messrs. Dunbar, McMaster, and Co., of Gilford, Ireland, Marshall and Co., of Leeds, and Thomas Ainsworth, of Cleator, Cumberland, exhibited linen threads of well-known quality, among which the linen floss of Messrs. Dunbar, McMaster, and Co. was especially noticeable.

The Scotch manufacturers contributed a different class of goods,—heavy and substantial fabrics, made of linen or jute, or both in combination, and

suited to all the ordinary purposes of life, such as table and bed linens, crash, huckabacks, and other toweling; butcher's linen, floor and stair cloths, paddings, shoe-linings, drills, osnaburgs, ducks, buckram, horse-cloths, grain and salt sacks, burlaps, bagging, carpet yarns, &c. Among the exhibitors deserving mention were Messrs. James Normand and Co., of Dysart, Fifeshire, William Laird and Co., of Forfar, and the Cox Brothers and Frank Stewart Sandeman, of Dundee.

Crossing the British Channel to Belgium, we find the exhibit of Jacques de Brandt, of Alost, especially noticeable for the beauty of design and accuracy of execution in damask table-linen. Messrs. Van Damme Brothers, of Roulers, showed indigo-blue linen of excellent quality, for blouses and pantaloon stuffs for the working classes. Rey, senior, of Brussels, contributed a very large and excellent variety of table, bed, and household linen, of medium fineness, but superior quality. William Wilford, of Tamise, exhibited very superior canvas, and the Govaert Brothers, of Alost, also showed good canvas, and bags remarkable for quality and cheapness.

France was represented in table linen by the house of Meunier and Co., of Paris, whose damasks were exquisite in design and workmanship; and in linen thread by Vrau and Co., of Lille, and Hassebroucq Brothers, of Comines, both exhibits being excellent for strength and evenness of fabric.

Holland sent a variety of substantial fabrics of flax for domestic use, all serviceable, but none especially noted for fineness or beauty of design. The exhibits of J. Eilas of Strijp; Nieuwenhuizen and Van Stratum, of Geldrop; J. H. Terhorst, of Ryssen; and L. Planteijdt, of Krommenie, were all noticed as useful and serviceable fabrics.

Sweden was represented by G. Stenburg's Widow, of Jönköping, who exhibited damask table-linen of good quality and beauty of design.

Germany sent a fine collection in the combined exhibit of the flax manufacturers of Würtemberg, of great variety and excellent quality; and Joseph Meyer, of Dresden, displayed damask table-linen of good design and fine finish.

Austria was admirably represented by the combined exhibit of Messrs. Regenhart, Raymann, and Kufferle, of Vienna, whose damask table-linen with coloured borders showed surpassing excellence in design, combination of colours, and workmanship in the execution. Carl Seigl, of Vienna, exhibited a variety of staple linen goods of great evenness and beauty.

Norway sent excellent canvas and twines from the Christiania Sail-cloth Manufactory.

Italy was represented by the table damasks and other fabrics of the Remaggi Brothers, of Navacchio, Pisa.

Portugal sent a number of exhibits of flax fabrics of various kinds, among which I have noted the linen drills of Bahia and Genro, of Oporto; the bed and table linen of Antonio de Costa Guimaraes, of Guimaraes; and Manuel M. R. Guimaraes, and the National Sail-cloth Company, of Lisbon.

Spain contributed table damasks of excellent quality, manufactured by Jaime Sadó, of Barcelona; hand-spun bed-linen by the Sons of Salvador Landa, Calatayud, Province of Saragossa, and a variety of flax fabrics from other exhibitors; also hemp shoe-thread of good quality, from Marques, Caralt, and Co., of Barcelona.

Russia, as might be expected, excelled in this branch. Her most noticeable exhibit was that of Messrs. Hille and Dietrich, of Girardovo, in the province of Warsaw, consisting of a great variety of fabrics,—colored damask table-linen of superior excellence in design and combination, fringed duck dessert and library cloths, bed and fronting linens, Turkish towels, ducks, and drills, etc., all of excellent and serviceable quality.

Baron Stieglitz, of Narva, exhibited very superior sail-cloth.

James Gribanoff's Sons, of Oostioog, province of Vologda, showed a very fine display of linen yarns and cloths, table damask, fronting-linen, and handkerchiefs, all of great excellence and beauty.

Lange & Co., of Moscow, had excellent samples of woven hose for fire purposes, and very good yarns and cloths were sent by Alexandroff & Alofoozoff, of Kazan.

Compared with the foreign contributions, the display from the United States was but small, and is noted as follows:—the Barbour Flax-Spinning Company,

of Paterson, New Jersey, exhibited linen threads, which in strength, colour, finish, and evenness compared favourably with the best English threads of Marshall. The American Linen Thread Company, of Mechanicsville, Saratoga County, New York, also made a fine display of threads and twines. The exhibit of woven goods was confined to the crash towelings of the Webster Linen Mills, of Webster, Massachusetts, and the stair-drills, by the same company and by the Stark Mills, of Manchester, New Hampshire, who also exhibited coarse diaper with flax warp and cotton filling. All these articles were useful and excellent in their way, but bore no comparison, as evidence of skill and progress, with the linen fabrics of Europe.

The United States possess every variety of soil necessary for the growth of flax, and half a century since, before the enormous development of the cotton manufacture, it was a common article of cultivation in many parts of the country, and was spun and woven by hand into domestic fabrics in many households. Acres of flax are now cultivated for the seed in many of the States of the Union, but the ripened fibre which is thus obtained is too coarse and harsh for manufacturing purposes. Good flax-fibre was, however, shown at the Exhibition, from Canada, and we believe its cultivation for the purpose of manufacture, and its conversion into yarn and cloth, to be one of the possibilities of the future, and one which will amply repay attention and examination by thoughtful men. It does not seem that the amount of hand-labour required to fit the fibre for the machines, now so largely employed for spinning, need be so great as to form an insuperable obstacle.

Fibres.

By Samuel Webber.

The best-known and commonly-used fibres of vegetable origin, other than cotton, are those of flax and hemp, of which the proportion shown by the United States was very small. Fair specimens were exhibited from West Virginia, Oregon, and Kentucky; but, as was remarked in relation to flax fabrics, the growth of the cotton manufacture seems to have entirely overshadowed this industry. Canada, also, sent two exhibits of flax of fair quality.

Nearly all the exhibits of these fibres of any consequence were from Europe.

Austria sent flax from Moravia, of excellent quality, and hemp from Hungary.

Italy contributed the finest specimens of hemp, from Bologna.

Holland showed three very fine collections of flax. Portugal was represented by forty-nine exhibitors of flax and four of hemp; some of the flax was short in fibre, but of very fine quality.

Spain had twenty-five exhibitors of flax and twenty-two of hemp, covering a wide range of length and quality of staple.

Russia contributed thirteen collections of flax and three of hemp, all of excellent quality; and Belgium sent two very fine exhibits of flax, of exceeding fineness and beauty.

A feature of great interest, however, was the display, from various tropical and semi-tropical countries, of fibres little known to us, except by their products, but which seem capable, by the application of suitable machinery, of becoming of immense value in the future, as subjects of manufacture.

The most noticeable of these was the Manila hemp, *Musa textilis*, from the Philippine Islands, which we usually see in the form of cordage, but which has a fibre capable, like those of flax and hemp, of extreme subdivision by proper treatment, being composed of a collection of finer fibres united by a glutinous matter, which is soluble in water, and admits of the reduction of the apparently coarse, long fibre exhibited (in some cases reaching twelve or thirteen feet in length) into a fibre sufficiently fine for delicate fabrics.

Samples of these fabrics were exhibited in the collection from the Philippine Islands, and were well worthy of attention.

In the same collection were also to be found numerous specimens of the "pina" cloth, and the fibres from which they were woven, as well as those of the banana, and other plants of the same genus. The fibres of the agave or yucca, from Mexico, were also very suggestive. Hammocks, nets, "grass-cloth" (so called), and paper of astonishing strength were exhibited by the local governments of Yucatan and Hidalgo, manufactured from this material; and its abundance in Mexico and Central America seems to make it a subject

worthy the notice of manufacturers, if some ready means can be discovered of cleaning the fibre from the fleshy part of the leaf.

Besides these there were a vast number of less known fibres exhibited, the "Phormium," or New Zealand flax, being the most familiar.

All the British colonies sent a greater or less variety of this and other fibres, the *Fourcroya gigantæa*, the ramie, the pita, the plantain, the banana, the pineapple, the wild fig, the aloe, the silk-grass, and the mahoe or hibiscus being among their contributions, forty-nine different varieties, including the above. being contributed from the Mauritius alone, and twenty-six from Queensland, Twenty different varieties were sent by Robert Prestoe, Esq., the Government botanist of Trinidad; eight from the Bahamas; and five from British Guiana.

Brazil also contributed several valuable fibres, the asclepias, urenas, palms (of different species), bilbergia, and fourcroya being the principal ones.

From Spain came a great variety of samples of the esparto grass, showing how largely it can be improved in quality by cultivation. This material is at present almost exclusively used for paper stock, but was shown to be available for a great variety of purposes. Hats, baskets, and other articles were exhibited, which had been made of it, and if, as reported, it will grow in the sand where nothing else will, it is worthy of attention. The Spanish-Portuguese Indian colonies, China, Japan, and Portuguese Africa also sent a variety of fibres, the ramie or China-grass being exhibited in fabrics in the Chinese and Japanese departments. Mats and matting from reeds, rushes, and other similar plants were shown by China, Japan, Spain, Portugal, and their colonies; and were deserving of praise for workmanship and ingenuity.

Those of us who can readily recall the whole history of the alpaca manufacture in Great Britain, and the adaptation of existing machinery, with slight modifications, to the purpose, by Sir Titus Salt, and who have also noted the enormous growth of the manufacture of jute in Scotland, in and about Dundee especially, can easily imagine that there is destined to be a great industry developed out of the manufacture of the Manila hemp, the sisal-grass, the ramie, and the American aloe; and, with this opinion, we can but think the display of the great variety of fibres at the Centennial Exhibition has been of great value in bringing them to the notice of practical men. There seems to be no more difficulty in applying existing machinery to these fibres than to alpaca or jute, if the fibres can be first freed from their woody or fleshy coverings; and that question does not seem to present any insuperable difficulty, though it may require time and patience to develop the most economical method.

GENERAL REPORT

ON

GROUP IX.

WOOL AND SILK FABRICS, INCLUDING THE MACHINERY.

JUDGES.

American.	*Foreign.*
John L. Hayes, Cambridge, Mass.	Gustav Gebhard, Germany.
Elliot C. Cowdin, New York.	Theodore Bochner, Jr., Austria.
Charles Le Boutillier, Philadelphia, Pa.	Henry Mitchell, Great Britain.
Charles J. Ellis, Philadelphia, Pa.	Max Weigert, Germany.
J. D. Lang, Vassalboro', Maine.	Louis Chatel, France.
	Carl Arnberg, Sweden.
	Hayami Kenzo, Japan.
	John G. Neeser, Switzerland.
	August Behmer, Egypt.
	Albert Daninos, Turkey.

Edward H. Knight was temporarily assigned from Group XXII to assist in examination of heddles.

GENERAL REPORT.

WOOL AND SILK FABRICS.

CLASS 667.—*Wool in the Fleece, in Bales, and Carded.*

Leading all nations in the supply of this material, the group of British colonies in the Southern Hemisphere, known as Australia, makes itself most conspicuous. The colonies of New South Wales, Victoria, South Australia, Queensland, Tasmania, Western Australia, and New Zealand, although separate political organizations, exhibit so marked a nationality in this common production, that we are compelled to consider them as one.

Foreign Judges, who were familiar with the great European Expositions, concur in pronouncing the exhibition of wools by Australia at the International Exhibition of 1876 as surpassing any ever before made. The colonies vied with one another in making their exhibits upon a scale proportionate to their vast power of production. Thus the wools of each exhibitor were shown in bales, in numerous fleeces, and illustrative samples, as produced from ewes, rams, hoggets, and lambs, as unwashed, cold-washed, and hot-water-washed, and as adapted for combing or for clothing purposes. Of course, the characteristic feature of the display was the capacity of Australia for the culture of wool of the Merino breed, adapted to the present exigencies of the manufacturing nations, for the exhibition of wool of other breeds by Australia was comparatively unimportant. The fibre of this breed was shown here in the utmost perfection, both in staple and condition, for all ordinary purposes of manufacture, with a production already of great proportions, yet constantly enlarging. When we consider the wide adaptation of this fibre to the uses both of luxury and necessity, and remember that it was for centuries the monopoly of a single nation, refused even to its colonies; that when Spain relaxed her monopoly, scarcely over a century ago, it was only in favour of the kings of Europe; and that the Merinos procured from Spain by George III., in 1792, in exchange for eight carriage-horses, were literally the direct source of the Australian wool-husbandry, we must regard the Australian exhibit as one of the most striking illustrations of the world's acquisitions within the last century.

The only deficiency attending this exhibit—one which the high culture and science of these colonies might have easily supplied—was the want of systematised information as to the statistics of wool-production and sheep-husbandry, the methods of improvement, and the details which would be interesting to the practical shepherd. This deficiency, in some respect supplied by the several Commissioners, and by personal inquiries and reference to trustworthy authorities, forbids the fullness of information in this report which the importance of the Australian wool-production demands.

The number of sheep in Australia, according to the latest returns, is stated in the following communications:

"St. George's House, Fairmount Park,
"Philadelphia, September 2, 1876.

"SIR,—With reference to your letter of the 28th ultimo, I beg to send you a copy of a letter which I have just received from Mr. Robinson, Secretary of the New South Wales Commission.

"I have the honor to be,
"Sir, your obedient servant,
A. J. R. TRENDELL.

"John L. Hayes, Esq.,
11, Pemberton Square, Boston, Mass."

[Enclosure.—Copy.]

"Philadelphia.

"SIR,—In reply to your letter of yesterday's date, covering a communication from Mr. Hayes, I have the honour to inform you that the number of sheep in

the Australian colonies in the year 1874, the latest year for which I have statistics, was as follows:

"New South Wales	22,872,882
Victoria	11,225,206
South Australia	6,120,211
Queensland	7,268,946
Tasmania	1,714,168
Western Australia	777,861
New Zealand	11,704,853
	61,684,127

"The number at the present time would be very much larger, but I regret that I cannot inform Mr. Hayes what is the average rate of yearly increase. The production of wool may be arrived at on the basis of the average clip, which I believe to be 2¾ pounds of washed wool for each fleece. If Mr. Hayes consults the export returns of the different colonies, it may be important that he should know that a large quantity of Queensland-grown wool is exported from Sydney, and that much of the wool grown in New South Wales is shipped from Victoria and South Australia, owing to their exceptional facilities for water and railroad carriage.

"The statistical returns of the different colonies would, without a knowledge of this fact, be very misleading, by the wool-production of Australia being made to appear vastly greater than it is in fact.

"I have the honour, &c.,

"CHAS. ROBINSON, *Secretary*,

"*New South Wales Commissioner.*"

The report of 1870, of H. Schwartz & Co., of London, very high authorities in wool statistics, states the exports of Australian wool in 1875-6 as follows:

Great Britain	771,786 bales.
United States	5,807 „
Continental Countries	2,414 „
Total	780,007 „

This amount, according to their estimates, is equal to 247,700,000 pounds.

The report for 1874, of Mr. Alexander Bruce, the chief inspector of live-stock in New South Wales, declared to be a high authority, gives the following instructive facts in relation to the sheep of that colony, and may be regarded as illustrative of all the colonies:

1. Number.—The number of sheep in the colony in 1874 was 20,709,338, and 22,767,416 in 1875, being an increase in 1875 of 2,058,078.

2. Combing and Clothing.—The returns give 6,100,000 combing sheep, and 5,490,000 clothing, while with respect to 6,420,000, it is not stated whether they are combing or clothing, and in many cases owners give no information.

3. Long-wooled and Cross-bred Sheep.—Of these some 125,000 are returned, and they are given as being of the following breeds: Leicesters, 15,881; Lincolns, 9,771; Downs and other breeds, 37,583; and Cross-bred sheep, 62,242.

4. How kept.—In 395 cases sheep are returned as depastured in paddocks, in 504 as shepherded, in 88 as both in paddocks and shepherded, and in 381 cases no information is given on this point.

5. Improvement.—On 681 holdings the sheep are reported to be improving, on 43 as deteriorating, on 72 as stationary, and 548 owners make no returns.

6. Stud Sheep.—The returns show that of these sheep there were 23,412 introduced; of which 18,086 were Merinos, 343 Leicesters, 4,741 Lincolns, and 42 Downs.

7. Fencing.—It has proved advantageous to inclose flocks within fences on the following accounts: *a.* Improvement.—(1) In the health and soundness of the sheep; (2) in their size and stamina; (3) in the quantity and quality of wool; (4) in the carrying capability of the holding. *b.* Saving.—(1) In expense of management; (2) in the losses arising from shepherding, especially from bad shepherds. *c.* Advantages to owner.—It relieves him from the trouble of managing shepherds and hut-keepers, and allows him time to attend to the improvement of the breed of his sheep. *d.* General benefit.—

This is stated by owners to be an increase of the value of a run of from 20 to 60 per cent.

8. Lambing.—The general average of shepherded flocks was 72¼ per cent.; of paddocked sheep 75 per cent.; and of sheep depastured both ways 74¾ per cent.

9. Clip.—The yield of wool per sheep, in 1874, was as follows:

	lbs.	ozs.
Greasy.		
The average clip of greasy wool in shepherded sheep was	4	$3\frac{4}{10}$
„ „ paddocked sheep	4	$15\frac{2}{10}$
„ „ both	4	$10\frac{7}{10}$
Creek-washed.		
The average clip of shepherded sheep was	2	$12\frac{6}{16}$
„ „ paddocked	3	$4\frac{2}{10}$
„ „ both	2	$12\frac{4}{10}$
Hot-water-washed.		
The average clip of shepherded sheep was	2	$8\frac{2}{10}$
„ „ paddocked	3	2
„ „ both	2	$11\frac{4}{10}$
Scoured.		
The average clip of shepherded sheep was	2	$2\frac{2}{10}$
„ „ paddocked	2	8
„ „ both	2	10

10. Difference in Weight between Combing and Clothing.—On this point 1,238 owners give no information, 75 "cannot say," 4 report that there is no difference, 32 that there is a slight difference in favour of combing; 4 put the difference at 8 ounces, 2 at 12 ounces, 1 at 16 ounces, 4 more at more than 16 ounces, and 6 state that combing is the more profitable.

The important facts presented by this statement are, that more than half the sheep produce combing wool; the respective weights of the greasy, creek-washed, hot-water-washed, and scoured wools; and the positive testimony, which should be specially noted by the California wool-growers, as to the advantages of fencing sheep. It is obvious that this must depend somewhat upon the nature of the feed and general custom of the country, and still more upon whether the flock-masters own the land or pasture at large. In this connection it may be noted that Mr. Bruce elsewhere states that the fence most approved for sheep and cattle is a fence with split posts, one split top-rail, and five wires.

South Australian Wool.

The following communication from the Commissioner of another colony, South Australia, gives interesting facts as to the weight of fleeces and extent of the flocks of individual flock-masters:

"Philadelphia, Main Building, 8th June 1876.

"To the Judges of Wool, *International Exhibition*, 1876.

"Gentlemen,—As Commissioner for South Australia, I have the honour to subjoin a statement of the weight of fleeces of wool examined by you in this court; taking first a copy of the declared weights of some wool in bales seen by you, and of which you have the growers' names, and then appending the weights of fleeces you desired should be weighed in the Main Building.

"1st. *Declared Weights of Wool exhibited, all Unwashed.*

"Moorak Wool. (W. T. Brown.)

No. of Bales and Classes of Sheep.	Contents in Fleeces.	Average Weight of Fleece. lbs.	ozs.	dwt.	Age of Sheep.
No. 1. Ewes	14	7	9	$2\frac{4}{14}$	3 years.
„ 2. Hoggets	15	7	3	$3\frac{3}{15}$	18 months.
„ 3. Lambs	20	2	12	$12\frac{11}{20}$	4 „
„ 4. Wethers	15	7	6	$6\frac{6}{18}$	2 years.

"N.B.—40,000 sheep are pastured at Moorak.

"WONOKA WOOL. (Hayward, Armstrong, & Co.)

No. of Bales and Classes of Sheep.	Contents in Fleeces.	Average Weight of Fleece. lbs. oz. dwt.	Age of Sheep.
No. 1. Ewes - -	14	7 1 $2\frac{4}{18}$	3 years.
„ 2. Hoggets - -	13	7 4 $14\frac{11}{15}$	18 months.
„ 3. Lambs - -	20	3 11 $3\frac{2}{20}$	5 „
„ 4. Wethers - -	12	8	3 years.

"WELPENA WOOL. (Price & Browne.)

No. of Bales and Classes of Sheep.	Contents in Fleeces.	Average Weight of Fleece. lbs. oz. dwt.	Age of Sheep.
No. 1. Ewes - -	11	7 11 $3\frac{2}{20}$	3 years.
„ 2. Hoggets - -	12	7 5 $5\frac{4}{12}$	18 months.
„ 3. Wethers - -	10	8 11 $3\frac{2}{20}$	3 years.
„ 4. Lambs - -	16	3 7	5 months.

"J. KEYNES WOOL.

No. of Bales and Class of Sheep.	Contents in Fleeces.	Average Weight of Fleece. lbs. oz. dwt.	Age of Sheep.
No. 1. Wethers - -	15	9 0 0	4 teeth.

"N.B.—13,000 sheep are kept by Mr. Keynes.

"ALLAN MCFARLANE WOOL (MF).

No. of Bales and Class of Sheep.	Contents in Fleeces.	Average Weight of Fleece. lbs. oz. dwt.	Age of Sheep.
No. 1. Ewe, with lamb -	15	6 well sorted.	3 years.

"N.B.—15,500 sheep are kept by Mr. McFarlane.

"COLLINGROVE WOOL. (J. H. Angas.)

No. of Bales and Classes of Sheep.	Contents in Fleeces.	Average Weight of Fleece. lbs. oz. dwt.	Age of Sheep.
No. 1. Ewes - -	Not stated.	6 1 0	2 teeth.
„ 2. Ewe Hoggets -	25	7 $10\frac{1}{4}$	2 and 4 teeth.
„ 3. Wet Ewes -	Not given.	Not given.	4 and 5 „
„ 4. Lambs -	„	„	Not given.
„ 5. Lambs -	„	„	„

"2nd. *Weights of Fleeces weighed in the Building, as requested.*

"Fleeces exhibited by J. Keynes. (Merino Wool.)

Fleece 1 weighs - - - -	11 lbs.	6 oz.	0 dwt.
„ 2 „ - - - -	10 „	12 „	11 „
„ 3 „ - - - -	10 „	11 „	8 „
„ 4 „ - - - -	12 „	7 „	8 „

"Fleeces exhibited by J. Murray. (Merino Wool.)

No. 1 weighs - - - -	12 lbs.	11 oz.	8 dwt.
„ 2 „ - - - -	12 „	2 „	8 „
„ 3 „ - - - -	15 „	11 „	0 „
„ 4 „ - - - -	14 „	5 „	0 „
„ 5 „ - - - -	15 „	13 „	0 „
„ 6 „ - - - -	15 „	3 „	8 „

" Fleeces exhibited by Thos. Graham. (Mixed Lincoln and Leicester.)

No. 1 weighs	13 lbs.	11 oz.	0 dwt.
„ 2	11 „	6 „	12 „
„ 3	11 „	15 „	0 „
„ 4	12 „	9 „	8 „
„ 5	10 „	2 „	0 „
„ 6	13 „	3 „	0 „

" I have the honour to be your obedient servant,
" Sam. Davenport,
" *Special Commissioner for South Australia.*"

A brief review of the methods by which the Australian sheep-husbandry has reached its present commanding position, with a presentation of some of the instructive facts in relation to the Merino culture drawn from Australian experience, is justified by the importance of the subject. The principal sources of this review are responses to personal inquiries, or information obtained from or confirmed by the respective colonial Commissioners. Of the works having this sanction, the most important are Mr. Graham's treatise on the *Australian Merino* and the *New South Wales Wool Inquiry*, published in 1871 by the Agricultural Society of New South Wales.

Captain John McArthur, an officer of the British army, who had landed at Sydney in 1790, just two years after it had been formed into a penal settlement, was the first to observe that the fleeces of the hairy Bengal sheep, brought from the Cape of Good Hope, had in some way become sensibly improved. Conceiving the idea that the soil and climate of the settlement were peculiarly adapted for the production of fleeces of the best quality, he induced the importation of a small flock of Merino sheep which had been sent to the Cape of Good Hope by the Dutch Government. In 1803 he took with him to England samples of wool from the crosses which he had made of coarse-wooled ewes with Spanish rams. At that period all the fine cloths of England were made of wool imported from Spain. Fortunately, Captain McArthur arrived in England at a time when the English manufacturers were alarmed lest their wool-supply from Spain should be cut off by a threatened war. Through the influence of these manufacturers Captain McArthur secured assent from the British Secretary of State for the Colonies to his application for a grant of ten thousand acres of land in New South Wales for carrying on the growth of fine wool for export. He also obtained a few Spanish Merinos from the royal flock of George III., these Merinos being the "twin Cabana with the French Imperial Cabana Rambouillet." Having arrived in the colony with his chosen flock, which was placed upon the tract of land secured by his grant, he commenced the reclamation of his estate and the creation of fine-wool flocks, through the persistent use of the George III. rams upon so sorry a lot of sheep that "long years were taken to eliminate the "bad qualities of the pristine animals, on which he bred." For years the only efforts for improvement were made by himself, and so slow was his progress "that it took some twenty-three years" to perfect the pure breed of Australian Merinos. In 1810 the exportation was only 167 pounds; in 1820, 99,415; in 1826, 806,302 pounds. The best growers in the colony "bred "from McArthur ewes." "From about 1829 to 1840," says Mr. Graham, "the Australian wool had a character so uniform and fixed that an English "wool-broker or sorter could with certainty select by the touch alone, from a "bale of others, a Botany Bay fleece, as they were called." The sheep, however, were small, the ewes weighing not more than 30 to 34 pounds each, and the wool wanting in denseness, the animals being bred mainly for fineness, in which they excelled. Smallness of size still appears to be the general character of Australian sheep, as shown by the average yield of unwashed wool per sheep in New South Wales,—4 pounds 9 ounces. After the time of Mr. McArthur, who died in 1834, many breeders, by selecting the largest and best-wooled sheep to breed from every year, and by keeping their runs understocked, or by liberal feeding, imparted size and density of fleece to the Australian Merinos, the ewes of some flocks attaining an average weight of 70 pounds.

After 1835, stud sheep were largely imported from abroad; and attempts were made to improve the Australian Merinos by crosses of the English races,

—the Leicesters, Lincolns, and Downs,—not only with signal failure, but with incalculable injury to the most of the Merinos.

The Rambouillet sheep were also largely introduced, but without benefit, in the opinion of Mr. Graham, because without artificial sustenance they were too large for the country. The German sheep, imported at great expense, produced no benefit either in quality of wool or weight of fleece. Recently, Vermont sheep have been introduced, and Mr. Graham says, "of all imported sheep those of our first cousins, the Americans, are the best."

The results of Australian experience would seem to show that climate has less to do with the excellence of Merino wools than is commonly supposed. The "Salt-bush" country (a region of excessive heat) can, and does in some instances, produce as heavy or valuable wool as do any other portions of the colonies; and wool of the Darling Downs within the tropics, grown by a careful and judicious system of selection, is unexceptionable, although known as a "hot country wool." Still, Australia confirms the theory of scientific writers, that the natural region for Merino sheep is the region of the vine, for the excellent wines of these colonies were among the most characteristic of their productions shown at the Exhibition.

Another lesson taught by the Australian sheep-husbandry, and confirmed by notes taken at the Exhibition, is the advantage of close breeding. Mr. Graham says that for a period of twenty-five years he was engaged in testing the value of in-and-in breeding. By in-breeding he does not mean indiscriminate breeding without selection, but, on the contrary, breeding with judicious selection,—that is, rejecting the faulty sheep, male and female, and breeding only from the perfect. With this qualification, he remarks, "I say that I never saw an entire flock of really good sheep that was not "wholly composed of in-bred animals, and I think it scarcely possible to "breed good sheep without having recourse to in-breeding."

It was interesting to observe that these views were confirmed by memoranda attached to Australian fleeces displayed at the Exhibition; memoranda made, of course, without reference to any theory of breeding. Some of these memoranda were as follows:

"Gore and Co., Yandella, Queensland. Combing ewe, bred pure within their own flocks for 21 years; bred in paddocks entirely on indigenous grasses."

"C. B. Fisher, East Haddington Hill, Darling Downs District, Queensland. This clip has been bred in Adelaide, South Australia, 40 years in-and-in to their own blood, and has been acclimated in Queensland 7 years; pronounced by Chamber of Commerce to be the most essentially combing wool."

"George Clark, Queensland. Sheep improved by Tasmanian Merinos bred pure for more than 50 years."

"C. H. Grison, Queensland. Bred within their own blood many years. Undoubtedly one object of this close breeding with large flock-masters is to preserve the special characteristics of the wool approved by their old controversies."

It is well known that so uniform are the characteristics in certain flocks, and so high the probity of the growers, that the clips of some proprietors are purchased by the same customers from year to year almost without testing. This uniformity and reliability is one of the great advantages to the manufacturer of having sheep-husbandry pursued on a large scale. He may select from one or two clips with certainty the precise wools adapted to his fabrics. This advantage has already been perceived in purchases from California, where wool-growing in large flocks has begun to be pursued by capitalists, as in Australia, systematically.

Sheep-husbandry being—not even excepting the gold-mining interests—of the first importance in the Australian colonies, is pursued by capitalists and men of intelligence. Relieved, as the proprietors are, from an expense of northern climates,—that of providing shelter and stores of winter fodder; winter production not being required, and the indigenous grasses being nutritious even when dried,—the principal outlay required in addition to that for stock is for providing an uninterrupted supply of water. The destructive droughts of 1866 have led to provisions for this supply on the broadest scale. Precautionary measures have been taken over the length and breadth of

Australia against the failure of water. At enormous expense, dry watercourses have been converted into permanent rivers, reservoirs and tanks have been constructed, wells have been dug and dams made, and the stations so provided with water as to prevent the recurrence of the catastrophe of 1866.

The expense of transportation to the very distant markets making the weight of the dirt and yolk of the wool a serious item, the washing of the wool on the sheep is conducted with a thoroughness nowhere else known. The washed wools, whether cold- or hot-water-washed, extensively exhibited at the Exhibition in bales and cases, could scarcely be distinguished from sound or absolutely clean wools.

Attention is given to every detail connected with the manufacture of wool, as in the shearing. The uniformity of the clipping in fleeces exhibited at the Exhibition, the steps usually made by the shears being scarcely visible, was the subject of favourable comment by our wool-growers; yet the price paid the shearers, reported in the official record of Victoria, is only 14 shillings 4 pence for every hundred animals shorn.

The *Wool Inquiry*, instituted by the Agricultural Society of New South Wales, is illustrative of the high intelligence with which the wool industry of the Australian colonies is pursued. The main subjects of the inquiry were, What descriptions of wool are now likely to be most in demand, and what are the best modes of preparing the wool and putting it in the market? Circulars containing interrogatories, all pertinent to the general question, were addressed to the most eminent wool houses and chambers of commerce of England. Full answers to these interrogatories by thoroughly-informed persons and commercial bodies in England are published in the *Wool Inquiry*. As the readers of this report will be principally those interested in wool-production we may be permitted to condense some of the most important points presented in these answers.

As to the distinction between combing and clothing Australian wools, writes one of the respondents, Southey, Baline, & Co., "All wools of Australian "production can be used for clothing, but by no means all for combing. "There are limits as regards length of staple, in the first place, and other "requisites, such as soundness and elasticity, necessary for the latter purpose. "It will be clear therefore, that, within these conditions, no line of distinction "can be drawn above or below which it can be said that this or that sample "is a clothing-wool and a clothing-wool only, a combing-wool and a combing-"wool only."

The committee, in their interrogatories, proposed for combing-wool the following points of excellence, or questions, which should distinguish a true combing wool, viz., 1st, weight; 2nd, colour or lustre; 3rd, length; 4th, freeness; 5th, fineness; 6th, elasticity; 7th, softness; 8th, soundness; 9th, evenness of fleece; and requested their respondents to divide a thousand points among them according to their respective values.

J. T. Simes & Co. reply: "Soundness is the first requisite in combing "descriptions; next, length up to three and a half inches for fine Merino. "This desideratum is a most essential one in combing descriptions. We "should place the characteristics of a Merino combing-wool in the following "order and value: Soundness, 300; length, 250; freeness, 175; weight, 100 "(important to growers); evenness, 75; elasticity, 50; fineness, 50. Lustrous "colour is scarcely an element in Merino combing."

H. Schwartze: "Soundness and quality, not singly but combined, con-"stitute the most valuable feature of a combing-, small growth and softness "that of a clothing-wool."

Hazard & Caldicott give the following statement of the relative importance of qualities in combing-wools: Length, 170; density, 60; softness, 80; fineness, 50; elasticity, 90; evenness of fleece, 80; soundness, 170; weight, 150.

A similar question was proposed by the Agricultural Society in relation to the desirable qualities of clothing-wools.

To this Jacomb, Son, & Co. reply: "The chief requisites of a good clothing-"wool are fineness, density, softness, and fitting qualifications."

H. Schwartze: "Small growth, softness, &c., combined, constitute the "most valuable features of a clothing-wool."

J. T. Simes & Co.: "Clothing-wool may be estimated by the following "points: Firmness, 300; softness, 200; density, 150; evenness, 100; "elasticity, 100; weight, 130; soundness, 50."

Hazard & Caldicott give the following statement for clothing-wools: Length, 50; density, 140; softness, 80; elasticity, 170; evenness of fleece, 80; soundness, 80; condition, 140: weight, 150.

As to the question whether combing- or clothing-wools are likely to be in most demand, the answers are substantially that the greater demand at present for combing-wools is due in some measure to the fashion for worsted coatings, but that no one can with certainty forecast the future. As to prices, it is said there is a difference of opinion, but the preponderance is that the best clothing-wools bring the highest prices, although they have less weight. As to shearing and shipping in grease, it is answered that this is almost wholly dependent upon local circumstances, such as the washing facilities at the station, though the washed condition is that most generally acceptable to various buyers and consumers. For uses in which colour is an important quality, the unwashed wools stand at a disadvantage, as there is "a greater "difficulty in procuring a bright colour from wools which have been packed "and shipped in the grease." The Bradford Chamber of Commerce decidedly recommends washing as "pecuniarily most advantageous to the grower."

As to cold or hot water washing, the preponderance of opinion appears to be, that there is very little to choose between the two processes where both are efficiently and skilfully applied.

In reply to the question, What proportion of yolk should be retained in the wool? all agree that just sufficient yolk should be retained to give a "kindly handle" to the fleece, the amount being variously put at from 10 to 20 per cent. Webster, Dewall, & Co., say "the sheep should be allowed 48 hours minimum run between washing and shearing, but in cold weather more time might be required. No yolk should be retained, but it should be allowed to rise again after washing to the extent of 20 per cent. After washing, the fleece should be allowed to dry thoroughly on the sheep's back, and only sufficient yolk should be allowed to rise to give the wool a soft and silky feel. In fact, the aim under all circumstances, whatever process of washing may be adopted, ought to be to give this soft, silky handle. The slight quantity of yolk tends to preserve the wool, and cause it to retain its natural elasticity and strength."

In answer to the question as to sorting and skirting and packing, the respondents recommend that "fleeces should be carefully skirted and stripped "of all locks, bellies, and stained, burry, or seedy pieces, great care being "taken that shanks or kimpy hairs are not folded in the fleece. The pieces "should include the pole-lock, belly-piece, skirting, and shank, and any portion "towards the extremities which are either stained or badly infested with burr "or seed, and by the removal of which the rest of the fleece will remain com-"paratively free from faults." In respect to the classing of wools, Mr. Schwartze says, "With very superior brands elaborate sorting is desirable. "In the case of medium and good wools, the separation into young wool, "first and second combing, first and second clothing, cross-bred lambs, "pieces, and locks is all that is required, while with superior and faulty wools "plentiful skirting is sufficient."

This long abstract of the *Wool Inquiry* will be excused, as it serves to answer questions directly presented to the observer by the peculiarities of the Australian wool exhibits; while the whole review of the Australian wool industry anticipates many points which would arise in considering the Merino wool-culture of other countries.

It is a natural inquiry whether the Australian wools will continue to increase in the accelerating ratio which has been witnessed in recent years. In the last decade the increase in New South Wales has been threefold, the numbers of sheep in 1866 being 8,132,511, while the returns for the year 1875 reached nearly 25,000,000. The Commissioners of this colony declare in their *Official Catalogue* that if seasons continue propitious, and prices are maintained at anything like the present rates, the probability is very great that another ten years will see New South Wales doubling the number of her sheep, and able to exhibit a return of 40,000,000 or 50,000,000.

Argentine Republic.

The country ranking second in importance in the supply of the wools of commerce is the Argentine Republic. The number of sheep, as stated by Dr. Oldendorff, the Chief Commissioner of this Republic at the Exhibition,

from a numeration made by himself as Commissioner of her Agricultural Department, is 57,501,200, with an annual yield of 216,000,000 pounds of wool, all of which, as there are only one or two wool manufacturers, may be said to be destined for export.

The details as to the numbers and distribution in the several provinces of this Republic, as furnished by Dr. Oldendorff, from the census of 1876, are as follows:

	Number.	Value.
Buenos Ayres	45,511,358	$72,818,172
Entre Rios	3,000,000	3,600,000
Santiago	1,200,000	960,000
Santa Fé	4,500,000	3,600,000
Corrientes	77,846*	878,000
Cordova	1,405,638	1,060,000
San Luis	113,815	170,000
Catamarca	114,420	145,000
La Rioja	53,932	108,000
Tucuman	70,000	56,000
Mendoza	53,856	94,500
San Juan	120,200	285,000
Jujuy	514,621	331,473
Satta	64,930	46,000
	57,800,616	84,152,145

The chief, though not to our own country the most important, portion of these exports consists of Merino wools. The exhibits of wools from the Argentine Republic, at the Exhibition, with the exception of that of Mr. Samuel B. Hale, scarcely did justice to the importance of this production. The most noticeable feature was the enormous size of some of the fleeces of Merino wool of the Rambouillet and Negretti stock,—one fleece, a pure-bred Negretti ram, grown in eleven months and eighteen days, weighed 31 pounds; other Rambouillet fleeces weighed 25 and 27 pounds. Two pelts were shown from sheep of the same race, one which measured 5 feet 6 inches in length, and 4 feet in width at the hips, with a staple 9 inches in length. These fleeces, although they may exhibit the recent attempts for improvement, do not illustrate the general character of the Merino wool of this country. The general characteristic of these wools is lightness of fleece, the weight not usually much exceeding three pounds in the grease to the fleece. They are fine, soft, and short, and principally suited for the card, though generally wanting in strength and nerve. Their principal defect, however, is the clinging to the fleece of the *carratilla* or burr from the clover or white medoc on which these sheep feed, which seems to be inseparably connected with the productive lands and best pasturage. Notwithstanding these defects, which are obviated by burring machinery, and more recently by chemical processes applied either to the wool or to the cloth, these wools are in high esteem with the cloth manufacturers, especially of Belgium and France.

The Argentine Republic vies with Australia in representing the results of the Merino wool culture in the last century. The raising of fine sheep was not seriously commenced until 1826, when it began with the importation of good Merino animals, with German shepherds, under the direction of Messrs. Hannah & Sheridan, whose establishment still survives. When fairly commenced the production increased with an accelerating ratio. The exports rose from 944 bales in 1832, to 3,577 in 1840, an increase of 280 per cent. in eight years. In 1850, it attained 17,069 bales, an increase in ten years of 380 per cent.

This Republic, with a climate where the cold of winter is so moderate as to exhibit no more severe effects than slight hoar-frosts which disappear with the morning's sun, with an extensive seaboard, an internal and arterial system of rivers counted among the finest in the world, and with a soil furnished by a rich and vast alluvial plain on a subsoil of silicious clay, would seem to have a capacity for an unlimited wool-production of Merino wool. It would be well

* This probably should have been 770,846, as indicated by the value.

if the same could be said of another branch of wool, the product of the same country,—that proceeding from the indigenous races, or rather the descendants of the coarse Spanish sheep introduced by the conquerors in the middle of the sixteenth century. These wools, proceeding from Churros sheep of Spain which have not been crossed with the Merinos, proceed from flocks found in the Sierra of Cordova, at an altitude of from three thousand to five thousand feet, also from other provinces of the Argentine Republic, as shown at the Exhibition, each known by the name of the province. The wool, long, though coarse, and produced in small fleeces, is in great demand in the United States for the manufacture of carpets. A plateau plain in the province of Cordova, of eight hundred superficial leagues in extent, at an elevation of ten thousand feet, produces sheep of this race which bear much larger fleeces of long carpet-wools. Some of the pelts were shown at the Exhibition. The tendency is for these wools to constantly increase relatively in value, as they are grown only by the rudest people, who are rather diminishing than increasing in numbers. The question of the future supply of these wools is, therefore, one of serious consideration with carpet manufacturers.

Three specimens of fleeces, "Lana de Lina," were also shown. These are the wools of the cross of the sheep and the goat. They resemble in appearance the wools of the sheep of the several provinces where they were grown, but are more wiry and slippery. Dr. Oldendorff, who is a man of thorough scientific and practical information upon all subjects connected with agriculture, and who has resided in Buenos Ayres for twenty years, being now the head of the agricultural department of the Argentine Republic, says that they are the offspring of the male goat and the ewe, never of the ram and the female goat, and are invariably sterile. The skins, dressed, are called *pellones*, and are used by the natives to cover their saddles. In travelling over the mountains, frequently eight or nine are put upon the saddle, on top of which the driver sits. They serve for his bed and covering as he bivouacs at night.

Cape of Good Hope.

The third great source in the Southern Hemisphere of fine wools of commerce is the colony of the Cape of Good Hope. The statistics, as furnished by Mr. Coates, the Commissioner of the colony, are as follows:—

Number of wooled sheep in 1875	10,064,289
Other sheep	944,050
Angora goats	972,733
	lbs.
Export of wool in 1875	43,000,000

From H. Schwartze & Co.'s Report, January 18, 1877, the following statistics in relation to the Cape of Good Hope are obtained:—

	1876.	1875	1876.	1875.
Imports.	Bales.	Bales.	lbs.	lbs.
England	169,908	174,598	42,054,712	44,170,950
Continent	1,033	997		
America	7,529	14,001		
Total	178,470	189,596		50,600,000

The imports into England are chiefly washed. They estimate the number of sheep at 16,000,000.

Chili.

No facts as to the wool-production of Chili could be obtained at the Exhibition. Statistical reports give its exports of wool for 1872 as 5,773,821 pounds, for 1873 as 4,102,078 pounds, and estimate the whole clip of the country at 3,000,000 kil., or 6,600,000 pounds.

Uraguay.

An official report of the exports of Montevideo (Uraguay) makes the whole—

	lbs.
Exports of wool	51,953,854
Imports from the Argentine Republic to be deducted	7,188,425
	44,768,829

Another statement gives the export as 57,042 bales; which, at 900 pounds per bale, the usual size for that country, would be equal to 51,637,800 pounds, from which are to be deducted 7,188,425 pounds imported from the Argentine Republic.

Peru and Bolivia.

There are no sufficient data in relation to these countries, The best estimates give the amount of 6,000,000 pounds for both.

Germany and Austria.

The exhibits of wool from Germany and Austria were limited to that variety of the Merino fleece commonly known as Silesian, but more properly called Electoral, from the Elector of Saxony, the country in which this wool was first produced. Some beautiful specimens of the Electoral fleeces were exhibited from Germany and Hungary, the latter grown by Hungarian nobles. They illustrated all the characteristic features of the "noble" wool, as it is sometimes called in Germany. The fibres of these wools, according to Mall, measure from 1·4 to 1·8 of a centime of a millimetre in diameter; a centime of a millimetre being equal to $\frac{1}{25\,40}$ of an inch. Nathusius Königsborn, in *Das Woolhaar das Schaf*, makes the average measure of 10 hairs 1·79 centimes, 1418 to an inch. Among these hairs one hair measured 1 centime, equal to 2540 to an inch. According to the same author, 18 hairs of a very high-blood ewe average 1·53 centimes, or 1661 to an inch. The finest single hair measured 1·17 centimes, equal to 2164 to an inch. The finest Silesian ram averaged 1·54 centimes. Dr. George May, in *Das Schaf*, Breslau, 1868, in a table of measurements of 55 different kinds of wool, gives the finest, that of a Silesian super-elector, the very highest Electoral wool, as averaging 0·13 millimetres, equal to 1954 hairs to an inch. The length of these wools rarely surpasses 4 centimetres, and the weight of the average of many flocks' fleeces is scarcely over 1½ pounds. They are used at present only for the fabrication of the most precious of woollen goods, imitation Cashmere shawls, extra fine broadcloths, &c. The thick felts, now made in this country for the hammers on the keys of pianos, are made solely of this wool imported from Silesia. It is admitted that this branch of wool-production is everywhere diminishing. Saxony, the cradle of the race, has scarcely any of the Electoral sheep. Silesia still possesses a considerable number, while others are found in Moravia, Hungary, Prussia, and Poland, which produce all the superfine wools used in Europe. The whole production of the superfine wools of these countries in 1866 is stated by a competent authority as follows:—

	Kilometres.
Hungary	560,000
Bohemia	110,000
Moravia	55,000
Silesia	85,000
Total	810,000

This small production is due to the small weight of the fleeces, the great care which the animals require, prices disproportionate to the cost of production, and the loss of that distinction which formerly encouraged the growers of the noble wool. Mr. Bochner, of Austria, one of the Judges of this group, is authority for the statement that Count Hunyady, of Hungary, one of the exhibitors of the Electoral fleeces at the Exhibition, produces

12,000 pounds annually of these wools, which he sells at 90 cents, principally in France, for the manufacture of imitation Cashmere shawls; but at these prices there is no profit in the culture. The few growers of this wool in Hungary, who are generally noblemen, continue the production only from motives of pride. Most of the wealthy proprietors, who formerly made a specialty of the production, have abandoned it or allowed their flocks to run down.

In no portion of the world have so much science and intelligence been directed to the Merino sheep-husbandry as in the German states. Saxony was the first to acquire the Spanish Merinos in any considerable number, first receiving them in 1765. In 1774, the pure-blooded progeny of the Spanish importations amounted to 325 head. As the culture of this race extended, there grew with it a desire to increase the characteristic property of the fleeces or the fineness of the fibre. This passion, as it became, for the utmost possible fineness of fibre, irrespective of all other considerations, led insensibly to the methods of breeding which produced a race possessing this attribute in the highest degree, but with a corresponding delicacy of constitution and lightness of fleece. This race, known in this country as the Saxon and in Germany as the Electoral, or Escurial, both names being used indifferently, does not appear to have been the inheritance from any special Spanish Cabañas, but a production of art. The commercial demand produced by the reputation of their wools led the German growers to increase the size of their animals and fleeces. Another race was developed by the size of the one above described, the ideal of which was a robust body producing the largest possible quantity of wool of the utmost fineness consistent with the increased production. This race was called the Negretti, from Count Negretti, the proprietor of one of the most celebrated original Cabañas in Spain. It was also sometimes called the Infantado race, from the Duke of Infantado, another Spanish proprietor; both terms, as in the case of the term Electoral and Escurial, indicating the character of the race and not its special Spanish descent, as it is often erroneously held. The descriptive terms Negretti and Infantado were found at the Exhibition applied to wools of the same general character. While Silesia is still in possession of the largest number of the superfine Electoral sheep to be found in the whole world, Saxony, Pomerania, Mecklenburg, and Eastern and Western Prussia in time renounced the Electorals and replaced them by the Negrettis. Thirty or forty years ago Germany attained the utmost production that her land would permit. In 1850, according to personal statements made to the writer by Professor Grothe, the number of sheep in all the German states exceeded 50,000,000; at the present time they do not exceed 25,000,000. Mr. Dodge places the number at 29,000,000. It is said that she is even losing her magnificent Merino breeds; for not only the Electorals, but the Negrettis, are being replaced by the English long-woolled races. What effect this will have upon the once famous broadcloth-manufacture of Germany is an interesting subject of inquiry; while the question suggests itself, what relation this decline of the German fine-wool-industry has to the abolition of the former protective duties on imported wool.

The estimated product of wool in Austria, according to the returns made at the Exhibition, is about 30,000,000 kilogrammes of 66,150,000 pounds. The number of sheep is not given; but at three pounds of wool per head the number would be about 22,000,000, Mr. H. Schwartze and Mr. Dodge give, from returns in 1871, the number of sheep as,—

In Austria - - - -	5,026,398
Hungary - - - - -	15,076,997
Total - -	20,103,395

The distribution of sheep in proportion to the area and population, in 1869, was as follows:—

	Per Square Kilometre-area.	Per 1,000 Persons.
Dependencies represented in the Reichsrath	2,476	367
Dependencies of the Hungarian Crown -	1,639	341
The Austrian Monarchy - - -	2,043	564

The largest flocks are found in Hungary. Beautiful superfine clothing-wool was exhibited by Count Alois Karolyr, from flocks bred at Stampfen. This flock numbers 80,000 head. The average length of staple of the fleece is about 1½ inch; the average weight of the shearings, the fleeces being warm- and soap-water-washed, is, winter lambs excepted, 2¾ pounds English. The whole clip, 145,000 to 156,000 pounds, is sold abroad, mostly to French manufacturers, for from 74 to 85 cents per pound.

Russia.

The wools of Russia were well illustrated at the Exhibition by numerous fleeces and bales, and admirably arranged samples. The most interesting were Electoral wools, comparing favourably with the Silesian and Hungarian specimens, samples of the Donskoi carpet-wools, and a series of beautiful samples from the estate of the Grand Duchess Katharine Michailoona, showing the extraordinary length of fibre obtained from sheep of the Rambouillet race. Sheep husbandry constitutes one of the most important branches of rural economy in the Russian Empire. The full statistics obtained from the Russian Commissioner show that the total number of sheep in the Empire at the present time is 65,387,000,—Europe 49,493,000, Asia 15,894,000, a number which gives a proportion of 81 sheep to each 100 inhabitants. The distribution of sheep according to the population in the great divisions of Russia is as follows:—

The population of Central Asia has per	100	inhabitants	- 565 sheep.
Caucasus	„	„	- 124 „
Siberia	„	„	- 90 „
Russia in Europe	„	„	- 70 „
Poland	„	„	- 65 „
Finland	„	„	- 49 „

Compared with the other great states of Europe, Russia occupies the fourth place.

Great Britain has per	100	inhabitants	- 133 sheep.
France	„	„	- 97 „
Prussia	„	„	- 93 „
Russia	„	„	- 81 „
Austria	„	„	- 47 „
Italy	„	„	- 38 „

The total number is composed of 12,555,000 head of Merinos, and 52,832,000 common sheep. The principal domain of the Merinos is comprised in the Government of New Russia, which forms the south-eastern portion of the empire. The Governments of Caucasus, Siberia, and Central Asia have scarcely any, and Finland no Merinos; Georgia and Circassia possess mostly sheep of the ancient Colchian race. Generally considered, the fine-wooled sheep tend to decrease, as the increased price of wheat causes a large conversion of pastures into arable land. Both the Electoral and Negretti races are grown. The small product in wool of the former race, set down at two pounds for the ewe and three pounds for the wethers, has led to extensive crossing with the more vigorous race. The most successful crosses, and those now in most favour, are with Rambouillet rams. The reason given for this predilection is, that "this wool responds best to the exigencies of the present wool-production, "since the clothing industry tends to decrease, while that of worsted tissues "takes daily more development."

The culture of Merinos in the southern regions of the empire is favoured by the mildness of climate, the sheep requiring shelter and fodder only about six weeks. The greater part of the flocks is composed of a great number of head, single flocks reaching to fifty, seventy-five, a hundred, and even four hundred thousand head. Mr. Falz Feru, one of the exhibitors of excellent wool of the Government of Tauride, in the Crimea, has 230,000 sheep, all of Spanish blood, occupying 340,000 acres of land. These flocks consist of Negrettis, which appear to have attained in Russia an unusual hardiness, which favours their culture in immense flocks, requiring but little of that care so indispensable for the Electorals.

The great masses of the common sheep are found in the countries of Central Asia, in the Governments of the south coast of Russia in Europe, in the Caucasus, and in Siberia. They consist of four races, Tchoundki, or the fat-tailed sheep, belonging to the nomadic people, the Kalmucks and Kurds. The Valaque, or the Walladean or Zakel sheep, which also abound in Hungary and Moldavia, of a large size, with coarse, lustrous wool. They are found in the Caucusus, or region of the Don, and probably furnish the wool known as Donskoi. The Tsijai, commonly spelt Zijah, meaning Gipsey, or mongrel, with an exterior resembling Merinos, but with longer wool. The Russian race, of a small size with coarse wool, and a sub-race, Retchelof, found at the south of the Government of Poltava, which furnishes the black and white fleeces commonly called Astrakan.

The production of the Merino wool of Russia in the grease is estimated at 1,569,000 poods, equal to 56,484,000 pounds; of common wool at 9,245,000 poods, equal to 332,820,000, or 6$\frac{3}{0}$ pounds to a sheep, the total having an estimated value of 46,357,000 roubles, or 32,449,000 dollars. The exports of wool are of a value of 13,999,534 roubles, supposed to be about 30,000,000 washed, equal to 50,000,000 pounds unwashed. There is a vast domestic consumption of common wools in the household for clothing, for carpets or mats, and for mattresses, while the sheepskins are largely used for clothing.

The enormous production of common wools, most of which, such as those from the broad-tailed and Valaque races, are admirably adapted for the carpet-manufacture, shows that this country will be one of the most important sources for the supply of the raw material for this industry.

France.

The wools of France had no representation at the Exhibition, except in fabrics and in the products of other countries which have been so largely influenced by an infusion of the blood of the French Merino. This influence makes it necessary to dwell at some length upon the French wool-industry, since it is one of the lessons of the Exhibition.

The sheep-husbandry of France is unquestionably declining, at least in numbers. President Thiers said in 1870, "Our ovine population has gone "down from 40,000,000 to 30,000,000." It is stated on the authority of the Inspector-General of Agriculture, that the number of sheep in France had been reduced from 30,386,000 in 1866, to 24,707,496 in 1876, a loss of 5,678,787 in six years. President Thiers attributes this decline to the absence of protective duties on wool, others to the abuse of an absurd law which allows the municipal councils to prescribe the number of head per *hectare* which each farmer is permitted to keep. The number of merinos, or their grades producing fine wool, is estimated by M. Sanson at 9,000,000. The other flocks, consisting of indigenous sheep producing coarse wools, and some English mutton-sheep, have no special characteristics worthy of notice.

The wool-industry of France is remarkable for the influence it has had upon the combing-wool manufacture of the world, and consequently upon the sheep-husbandry of all the nations which supply it. Louis XVI. obtained from the King of Spain 200 rams and ewes of the pure race of Leon and Segovia, exactly a century ago, viz., 1776. In 1786 he obtained 367 more, which were the foundation of the famous Rambouillet flock. In 1799 France received, through the treaty of Basle, 5,500 animals from the finest flocks of Castile. Sixty sheep-folds were established by Napoleon as accessories to that of Rambouillet, where proprietors could obtain the service of Merino rams free of charge. The directors of the national sheep-folds pursued in breeding precisely the opposite course to that adopted with the same original race in Saxony and with the *Tropeau de Naz* in France. They aimed to increase the size of the frame and the weight of the fleece. With this increased size and weight there was developed a corresponding length of fibre, and a Merino combing-wool was for the first time created. The French manufacturers were the first to avail themselves of this new property of wool which their own territory supplied. National pride stimulated them to create new fabrics from the new material supplied from domestic sources. They invented Mousselines de laine Merinos, cashmeres, *challis*, bareges, and more recently worsted coatings, in a word, all the woollen stuffs of the nineteenth century which distinguish themselves in their physiognomy from the tissues of the preceding centuries. The English and other manufacturing nations in due course

followed the French example. Wool, instead of furnishing the material for clothing for one sex, as formerly, supplied it for both. The Southern Hemisphere responded to this new and increased demand for Merino wool, and the fine sheep-husbandry of the world was modified to produce the combing-wools required for the new fabrics. To France must be accorded the honour of creating the most characteristic feature of the sheep-husbandry and wool-manufacture of the present century.

The scientific breeders of France, not contenting themselves with producing animals surpassing all others of their race in size and weight of fleece, and length of staple, have more recently aimed to develop, together with the special qualities of the Merino fibre, the meat-producing qualities and precocity of development, which formerly were regarded as the exclusive aptitudes of the English races. They have succeeded in transforming the Merino into the most perfect mutton-sheep, having the same precocity and giving as much meat as the South Downs, reputed to be the best producers of flesh, while, at the same time, the total weight of the fleece is increased without augmenting the diameter of the fibre. In a word, the Merino, while becoming a mutton-sheep, preserves all its wool-bearing qualities. This method of development, requiring of course abundant food, should be suggestive to the occupants of the valuable lands in this country contiguous to city markets, where the merely pastoral sheep-husbandry has declined.

We must not pass by another product of French sheep-husbandry, perhaps the most instructive, in a scientific point of view, of any in the Exhibition, as illustrating the wonderful results which skilful breeding may accomplish by happily improving the accidents of nature. The product referred to is the famous Mauchamp wool, admirable specimens of which, both in staple and yarn, were exhibited by Mr. George W. Bond, who had personally visited the creator of this race in France, from whom he obtained his specimens. The characteristics of this wool are that to a fineness equal to that of Merino, and a length of staple which surpasses it, is added a lustre absolutely comparable to that of silk; a lustre so marked that, in a *challis* made with a silk warp and weft of Mauchamp wool, the stuff, which contained only one-eighth of silk and seven-eighths of wool, was as brilliant as if made entirely of silk.

The history of the creation of this race is so instructive that it may be briefly stated. In 1828 there was accidentally produced on the farm Mauchamp, in France, cultivated by M. Graux, a ram from a flock of Merinos, having a head of unusual size and a tail of great length, and also a wool remarkable for its softness, and, above all, its lustre. M. Graux separated the animal from the flock and used it for reproduction, obtaining some animals similar to the sire and others to the dam. Taking afterwards the animals similar to the sire and crossing them among themselves or with the sire, which served for the type, he succeeded, little by little, in forming a small flock whose wool was perfectly silky. He afterwards succeeded in modifying the forms and the size of the animals, originally quite small, and attained a flock of six hundred head, all furnishing the silky wool. The flock was prosperous at the time of the breaking out of the Franco-Prussian war. Of its history since that period we have no knowledge.

England.

The English wools were illustrated at the Exhibition by the beautiful collections of the wools of commerce of Messrs. Bowes, of Liverpool, and Bond, of Boston; and, at a later period, an admirable series of fleeces forwarded from Bradford, through the influence of one of our colleagues, Mr. Mitchell. The names and prices of these wools are given below:

Half-bred wether	-	15½	pence.
„ hogget	-	16½	„
Somerset wether	-	16½	„
Lincoln „	-	16	„
Northampton wether	-	15½	„
Yorkshire „	-	16½	„
Half-bred hogget	-	16½	„
South Down ewe	-	16	„
Leicester wether	-	16	„
Shropshire hogget	-	16½	„
„ „	-	18½	„
Northampton hogget	-	16½	pence.
Kent wether	-	16½	„
Northumberland hogget		17½	„
Gloucester hogget	-	16	„
„ wether	-	15	„
Somerset „	-	16	„
Irish hogget	-	17½	„
Devon (lustre) wether	-	17½	„
Hereford „	-	16½	„
Yorkshire hogget	-	19	„
Lincoln „	-	18	„

The characteristics of the fibre of all the many English races were well displayed in these collections. It is necessary to say that England produces no Merino sheep, and that all are grown primarily for mutton, and secondarily for the wools, the latter being generally used for combing purposes, and entering into the manufacture of a large class of worsted goods. The wools of English races,—the Leicesters and Lincolns and Cotswolds,—for length, strength, and lustre, present the best type of combing-wool proper, or that used exclusively for combing-wool purposes. The lands being stocked with sheep to their utmost capacity, the numbers of sheep vary but little from year to year, so that returns of a few years back will pretty fairly represent the present production. The Government returns of 1868 show the whole number in England, Wales, Scotland, and Ireland to be 34,532,000, which are classified by Mr. Graham as follows, according to the leading typical races:

Leicesters and their allies	12,933,000
Downs	6,130,000
Cheviots	4,368,000
Black-faced	5,101,000
Welsh	2,000,000
Irish	4,000,000
	34,532,000

The production of these races is thus estimated:

Leicesters	12,933,000	fleeces at 7 pounds each	90,531,000
Downs	6,130,000	„ 4 „	24,520,000
Cheviots	4,368,000	„ 3 „	13,104,000
Black-faced	5,100,000	„ 2¾ „	14,027,750
Welsh and Irish	6,000,000	„ averaging 2 pounds	12,000,000
	34,532,000		154,182,750

At an average price of 10 pence per pound, the value of the wool-product is 6,425,000*l.* Taking the average age of these sheep at three years, about one-third, or 11,510,000, are killed for mutton annually; averaging the carcase at 65 pounds and the price per pound 8 pence, there are produced annually 748,150,000 pounds of mutton, realising 25,000,000*l.* per year. This added to the annual value of wool, 6,425,000*l.*, makes the product of British sheep 31,425,000*l.* or $159,125,000. To this is to be added the value of the manure, which can only be estimated by the fact that it is an indispensable necessity for British husbandry. This estimate is greatly increased when we add the value of wool from slaughtered sheep, say 36,000,000 pounds, and estimate the value of the wool at 15 pence instead of 10 pence, which is nearer the correct figure at the present time.

The Dominion of Canada.

The long wools of English blood exhibited by Canada attracted the high commendation of the Judges; an exhibit from Hamilton showing Leicester, Cotswold, and South Down wools, and that of crosses of Leicester and Merino, Leicester and South Down, Cotswold and Leicester, Lincoln and Cotswold, justified the popularity of these wools with the worsted manufacturers of the United States. So prevalent is the culture of the long combing-wools in Canada, and so large their consumption in the United States, where they find their principal market, that the term Canada Wools is in general use to designate the wools of the English type.

We are indebted to the Minister of Agriculture of the Dominion of Canada for the latest official returns, made in 1871, which furnish the following statistics as to sheep and wool production:

Provinces.	Number of Sheep.	Pounds of Wool.
Ontario	1,514,914	6,411,305
Quebec	1,007,800	2,763,304
New Brunswick	234,418	796,168
Nova Scotia	398,377	1,132,703
	3,155,509	11,103,480

Other European Countries.

No exhibits of wool were made by Italy, which, according to Messrs. H. Schwartze & Co., has 6,977,104, and according to Mr. Dodge, 11,000,000 sheep. Portugal, which has about 3,000,000 sheep, made some excellent exhibits, and is declared by her Commissioners to be pursuing sheep husbandry with a freshly awakened zeal and energy. Spain, which has, according to both the authorities above mentioned, about 22,000,000 sheep, made a considerable number of exhibits of wool. But the observer could not fail to be struck with the fact that the Merino wools exhibited by the country which was the cradle of the Merino race, showed no evidence of their pristine excellence.

United States.

It is a subject of great regret that the wools of the United States were so inadequately represented at the Exhibition. This was in some measure accounted for by the circumstance that the usual shearing had not taken place at the time when, by the rules of the Exhibition, the entry of exhibits was closed. At the request of the Judges of this group, an extension of time was granted to proposed exhibitors of wool, but with little effect. The few beautiful fleeces, especially from Ohio, but more than all the high character of American flannels, blankets, and fancy cassimeres, made exclusively of domestic wool, were sufficient to impress our foreign associates with the value of our wool-product.

The number of sheep in the United States is set down in the Census returns of 1870 at 28,777,951, and the quantity of wool produced at 100,102,387 pounds. It is believed that these returns are incomplete, as they only give an approximation of the number of sheep actually on farms at the dates of the returns, and were imperfect in respect to Texas and the Territories, while the amount of wool is also incomplete, as the return of fleeces of sheep slaughtered in cities are not given.

The statistician of the Agricultural Department, Mr. Dodge, whom the writer has consulted, and who has made a special study of the subject, estimates the number of the sheep in the United States, in 1876, at not less than 36,000,000, producing, with the additional fleeces of those slaughtered within the past year, 155,000,000 pounds. The sheep of the United States consist, 1st, of what are called the native sheep, which are descendants of the unimproved coarse-wooled English sheep, first introduced. It is not known to what particular type of the English races they originally belonged, although it is known from tradition that certain of the common sheep were held in particular esteem for producing long worsted wools, which were hand-combed and spun in the families of New England for making yarns for worsted stockings. These sheep furnished the stock upon which the Merinos were engrafted. 2d. Descendants from the more recent English races, principally brought immediately from Canada. 3d. The Mexican sheep found in Texas, New Mexico, Colorado, and California, a coarse and sparsely-wooled sheep of Spanish descent, undoubtedly the race known as Charro. 4th. The Merino sheep and other grades. The latter constitute the principal and characteristic sheep of the United States. Six Merinos were introduced to the United States by different persons between 1793 and 1802. In the last-named year Mr. Livingston, the American Minister in France, sent home two pairs of Merinos obtained from the French Government flock. Later, in 1802, Colonel Humphreys, the American Minister in Spain, on his return from his embassy, shipped a flock to the United States, of which twenty-one rams and seventy ewes reached his farm in Connecticut. It is not known whether the Merinos imported prior to these left any descendants, although it is known that the Merinos proceeding from the import of Mr. Livingston sold for enormous prices. The next, and by far the most important acquisition, was secured in 1809–10, through the energy and fortunate position of Mr. William Jarvis, American Consul at Lisbon, in Portugal. In consequence of the invasion of Spain by the French, and the subsequent confiscation and sale by the Junta from celebrated flocks of Merino sheep, Mr. Jarvis was enabled to purchase a large number,—about 3,500,— which he sent to this country and sold, except a few hundred, which he placed on his own farm in Wethersfield, Vermont,

where they or their descendants have remained ever since. Four of these sheep were presented to Mr. Jefferson, at Monticello, who thus responded: "The "four Merinos are now safe with me here, and good preparations are made "for their increase the ensuing year. Pursuing the spirit of the liberal donor, "I consider them deposited with me for the general good; and divesting "myself of all views of gain, I propose to devote them to the diffusion of the "race throughout our State, as far as their increase will permit. I shall send "a pair to every county of the State, in rotation, until the whole are possessed "of them." In 1810 and 1811 there was an additional importation of about 2,500 Merinos, all from the prime flocks of Spain, part of which went to New York and part to Boston. The Merinos arrived at a propitious time for their favourable reception. It was a period when our foreign trade was suspended by the embargo, and our people were driven to supply themselves with fabrics from their own resources. They hailed with eagerness the opportunity of supplying and improving the raw material for the wool manufacture in which they had embarked. The Spanish races were eagerly sought to improve the common sheep, and flocks of full blood and grades were established in all parts of the country. Although the mania for Merino growing, which rose so high during the war of 1812 that from 1,000 to 1,500 dollars was not unfrequently paid for Merino bucks, was checked by the peace of 1815, and the destruction of our wool manufacture by the flood of importations, while many of the flocks were merged in the common coarse sheep of the country, others were kept pure and separate, and the race was firmly established on our soil.

In 1824 a new impulse was given to our wool manufacture through legislative influences. Factories on a large scale were established for making broadcloths. The fashion of the times required cloths of great firmness, such as were made in England and France from the wools of German Electoral sheep-husbandry, which was then at the height of its prosperity. The necessities of the broadcloth manufacture required a finer wool than was supplied by Spanish Merinos, as they then were commonly called. Saxon, or Electoral Merinos, were imported in large numbers. The record is preserved of 2,963 which were imported in four years. The first aim of the wool-growers thence for a period of fifteen years was to engraft upon their flocks the Saxon blood, though, fortunately, a few never entirely abandoned the old Merinos.

Through the effect of general causes, which insensibly led to the decline of superfine sheep-husbandry in all the Merino wool-producing countries of the world, there commenced in the United States about 1835 a reaction in favour of the neglected old-fashioned Merinos. Intelligent growers abandoned improvement through the Saxon stock, and sought for stock animals those of undoubted descent from the early Spanish importations. From this period the improvement of the American Merinos, as they began to be designated, especially in weight of fleeces, was rapid. To give an illustration by no means exceptional, in 1835 the choicest flocks yielded 4½ pounds of wool per head. In 1844, flocks of the same proportion yielded 5 pounds 13 ounces of washed wool per head. In 1863, a flock of 157 two-year-old and yearling ewes yielded 7 pounds 2 ounces of fairly washed wool per head. In that year, at the International Exposition of Hamburg, the first prizes for the best heavy-wooled sheep—rams end ewes of 1,761 competing animals—were awarded to Mr. Campbell, of Vermont, who exhibited American Merinos. In 1875, a flock of 33 ewes in Michigan produced 318 pounds of washed wool. At the American Wool-Growers' Association, in 1875, the premiums were awarded with the following report:

	Weight of Sheep.	Weight of Fleece.	Age of Fleece.
1st premium ram	180½ lbs.	29 lbs.	11 mo. 21 days.
2nd premium ram	148 „	23 „ 13 oz.	1 year 4 „
1st premium ewe	108 „	17 „ 3 „	11 mo. 22 „
Two-year-old ewe not entered for premium		22 „ 8 „	1 year 5 „

Two races of our Merinos have acquired special celebrity: the Atwood family improved, descended from Colonel Humphreys' importation, and supposed, upon somewhat equivocal authority, to be of the ancient Spanish stock belonging to the Duke Supantado, and the Rich family, supposed to inherit Paular blood. All these alleged descents are believed to be equivocal and uncertain. The Wells and Dickinson, of Ohio, partially descended from

Colonel Humphreys' sheep, samples of whose excellent wool were shown at the Exhibition, have had much influence upon the early flocks of the Western States. The most eminent improver of the American Merino was Mr. Edwin Hammond, of Vermont, who bred upon the Atwood stock. Of his work it is enough to say that he effected as marked improvement in the Merino as was made by Bakewell and Elman respectively upon the Leicesters and Downs of England.

We find, in this brief review, the names of Livingston, Humphreys, Jarvis, and Hammond, who are to be specially honoured as founders of American sheep-husbandry. To these should be added that of Henry S. Randall, of Cortland Village, New York, recently deceased, at once a practical shepherd and a scholar. His example and his writings, which have contributed so much to elevate the pursuit of wool-growing in this country, are among the best fruits of American sheep-husbandry.

The special application of American wools will be considered under the head of fabrics. We will advert to one general attribute which is universally conceded to them, viz., their soundness and strength of fibre. This, and perhaps the great development of fleece and weight, are to be attributed less to skill and the character of our soil and climate than to the prevailing system of keeping and the careful and thrifty habits of the people. The flocks, being generally small, are under the personal care of the proprietors. They are housed in winter and regularly and abundantly fed, and consequently produce a healthy and sound fibre. Thus our wools owe their best distinguishing attribute indirectly to social or moral causes. It would be seen that our Merino wools, as a rule, belong to the class of intermediary wools produced in Europe by the Negretti race, now generally prevalent in most Merino wool-producing countries and increasing in others. Many of our manufacturers complain of the falling off of our fine wool production. The American wool-grower has seen little at the Exhibition to induce him to change his present system. He has found that the cloth-industry of the world is adapting itself to the intermediary wools such as he produces. Even fashion yields to economical necessities. The superfine wool-production is unnatural, artificial, and unprofitable. From the nature of things there can be no reasonable expectation of seeing it revived in this country. So small is the consumption of the superfine wools that what might be imported from abroad would hardly compete with American wools; and if it were possible to distinguish them so that there should be no possibility of fraud or evasion, they might without injury to the wool-grower be placed on the same scale of duties as carpet-wools, neither being advantageously produced here.

The reader would naturally look for particulars as to the distribution of sheep in the several States of our territory, with observations as to the characteristics of the wool in the different States as influenced by soil and climate. These particulars the writer hoped to supply, and with this view addressed letters of inquiry to each of the Commissioners from the wool-growing States. The information obtained was so meagre that he has been compelled to abandon his purpose. The wools of many of our States have characteristic qualities readily recognised by inspection or touch; but the most skilled expert would be unable to define, in language intelligible to the unskilled, differences which to him are perfectly palpable.

The deficiency as to the distribution of sheep in the several States, is approximately supplied by a statement which accompanied an admirable exhibit of samples of wools from most of the States and Territories of the Union, made by Messrs. Fiss, Banes, & Erben, of Philadelphia. This exhibit, made at the special request of the Superintendent of the Agricultural Department of the Exhibition, was received too late to obtain the official award it deserved. The samples were well arranged and exceedingly instructive, especially as supplemented by the estimates of the number of sheep, which these gentlemen were so capable of giving with near approach to accuracy. This estimate is as follows:

	Number of Sheep.		Number of Sheep.
California	6,750,000	Iowa	1,663,900
Delaware	23,600	Kansas	123,900
Georgia	271,200	Kentucky	683,600
Illinois	1,311,000	Louisiana	68,800
Indiana	1,250,000	Maine	225,900

	Number of Sheep.
Maryland	141,200
Massachusetts	76,300
Michigan	3,450,600
Missouri	1,284,200
Nebraska	48,900
New Hampshire	242,200
New Jersey	125,800
New York	1,936,500
Ohio	4,546,600
Oregon	710,500
Pennsylvania	1,640,500
Rhode Island	25,300
Tennessee	341,700
Texas	1,691,500
Vermont	490,500
Virginia	356,400
West Virginia	544,500
Wisconsin	1,162,800
	Not given, Census of 1870.
Colorado	120,928
Utah	59,672
Wyoming	6,409
Montana	2,024

The following States and Territories were not represented. We place against them the number of sheep in 1870, since which time some of them have immensely increased their flocks:

Connecticut	83,884
Minnesota	133,343
New Mexico	619,438
North Carolina	463,435
South Carolina	124,594
Washington Territory	44,063
Mississippi	232,732
Florida	26,599

There are some general considerations relating to American sheep-husbandry not yet referred to which should not be omitted. Sheep-husbandry in the older States is apparently declining, or is rather in that condition of suspense which precedes a transition to another form. In most of the New England States the number of sheep has greatly diminished, as in Connecticut, New Hampshire, Rhode Island, and Massachusetts. Vermont, however, still occupies an important position as a sheep-producing State, and in one respect is the first. The distinctive character of the sheep-husbandry of Vermont is the breeding of Merino sheep, and especially of rams, for exportation to other States and abroad. The influence of Jarvis and Hammond, and of the choice flocks of the purest Spanish races, introduced by the former, is felt throughout the State. The objection has been made to the Vermont Merinos that with the object of obtaining heavy fleeces there has been an undue development of yolk. The best breeders, prominent among whom is Mr. George Campbell, of Westminster, are now working in a different direction. They are breeding so as to destroy the wrinkles formerly so popular as indicating a pure blood, but really useless, unsightly, and inconvenient in shearing, to diminish the quantity of the yolk, and to make a hardy animal, fitted especially for re-generating the flocks kept in a state of exposure in Colorado and California. Vermont sheep at the Exhibition having attracted the favourable attention of the Commissioners from Australia, the wool-growers of the State subscribed for the purchase of a model ram and ewe, which they have courteously presented to the Agricultural Society of New South Wales.

The most remarkable event in the recent history of our wool-industry, is the rapid development of the pastoral sheep-husbandry in California and the trans-Missouri States. While in the oldest States wool-growing has been pursued with small flocks, as an adjunct to other husbandry, in these states it has been organised on a grand scale. It is conducted not by farmers, but by exclusive wool-growers, who are at the same time capitalists. There are single proprietors who have flocks exceeding a hundred thousand head in number. In 1868 the Pacific product was 15,000,000 pounds; in 1870, 23,000,000. In 1875 the product of California exceeded 50,000,000. The product for 1876 is stated as follows by E. Grisar & Co.:—

Spring wool, 94,102 bales, weighing	28,230,000 pounds.
Spring wool shipped direct from the interior	1,834,919 „
Total spring production	30,064,919 „
Fall wool received, 73,952 bales, weighing	24,031,378 „
Fall wool shipped direct from the interior	204,073 „
Total fleece wool	54,300,370 „
Pulled wool shipped direct from San Francisco	2,250,000 „
Total wool production of California in 1876	56,550,370 „

The wool is rapidly improving and is in high demand. The great ranges of pasturage in the Pacific and trans-Missouri States, and the very little winter housing and feeding of forage required, give promise of a development of sheep-husbandry in those territories comparable to that of the Southern Hemisphere.

Conditions not less favourable, which are beginning to attract the attention of experienced wool-growers, exist in the vast area and favourable climate of Texas.

No reference has yet been made to a branch of our sheep-husbandry which promises to take the most prominent place in the older States, that of the long-wooled or mutton races, or their crosses with Merinos. The culture of these sheep, which are of recent introduction, dating back hardly more than twenty years, has been largely influenced by the contiguity of Canada, and the development of our worsted industry within the period mentioned. It has been peculiarly successful on the southern shores of Lake Erie, and in the states adjoining Canada. From returns furnished by the State Commissioners, it appears that of about 11,000 sheep in Wisconsin, about one-quarter are of the long-wooled races. Of 8,000,000 pounds produced in Michigan in 1875, about one-quarter is of the same race. In both States the culture of this wool is declared to be on the increase.

In Oregon, of 2,000,000 pounds produced in 1875, the quantity of long combing-wools was in the same proportion. The exhibits from this State show remarkable success in breeding, actually improving upon the English wools, while the climate shows peculiar adaptation to this product. Kentucky, favoured by its blue-grass pastures, is also distinguished for the excellence and abundance of its long combing-wools. It has been proved by the best test, that of actual trial, contrary to the belief formerly prevailing, that our soil and climate are well adapted to these heavy sheep. The high prices of the wools, the increasing demand for good mutton, and the benefits to the soil, cannot fail to induce the farmers of the older sections of the country to follow the example of England. A new feature in our foreign commerce is the recent invention which permits the transportation to great distances of fresh meats, hung on shipboard in apartments suitably prepared, and the favour which American beef and mutton thus introduced have met in England presents unexpected inducements for mutton-growing in our Atlantic States.

Other English races not yet introduced, especially the Cheviot, should be tried. It is believed that this race is specially fitted for the high plateaus of North Carolina, where they would find a climate approximating that of their native locality. The mere acclimation and continuance of the English types is not sufficient. Attempts should be made to create new races of this class of sheep exactly adapted to our climate, manufactures, and conditions of agriculture. No wider field for zoötechnic achievements is offered than in this direction.

This sketch would be incomplete without some reference to the literature of American sheep-husbandry. The most eminent and influential worker upon this subject is Dr. Henry S. Randall, lately deceased, who by his writings and example has done more than any other to elevate what was once a neglected and accidental pursuit of the farmer to a cherished and dignified employment. His *Practical Shepherd* has been pronounced the best book ever published on any branch of agriculture. Other eminent writers on this subject are Mr. George Geddes, whose contributions have appeared in the *New York Weekly Tribune*; Mr. A. M. Garland, of Illinois, the editor of the sheep department of the *Live Stock Journal*,—at present the fullest and most trustworthy source of information available to American wool-growers; and Messrs. Glenn & Co., of Pennsylvania, contributors to the *Practical Farmer*.

The Bulletin of the National Association of Wool Manufacturers, in six volumes, has notices of much of the foreign literature bearing upon the subject, with discussions of the economical questions connected with American wool-industry. It contains, besides, essays by Mr. George William Bond. Several of the most recent reports of State Boards of Agriculture contain essays of much value, particularly those of the States of Maine, Vermont, and Georgia. The reports of the National Department occupy the first position as sources of knowledge on the subject of sheep-husbandry.

Résumé of Wool Production.

Messrs. Helmuth, Schwartze, & Co., of London, in their annual report dated January 18, 1877, say as follows :—

"An attempt is made in the following to give a survey of the wool trade in its largest proportions. Usually the view is confined to one market or to one country, or to colonial or home-grown wools, as the case may be. Here, however, the circle is expanded to include all wools and all countries, as far as information reaches or even as data exist upon which reasonable guesses may be based. To arrive at such a view, the most obvious way would have been an inquiry into the total quantity of wool produced in the world. But, though we give an estimate of the number of sheep in existence, the figures are in several points too uncertain to allow of any conclusions being built upon them. It is nevertheless possible to obtain a view of the trade in its entirety in another way, viz., by ascertaining not the production of wool which takes place all over the globe, but the quantity worked up by the whole wool-industry, which, so far from being distributed over the whole earth, is in a developed form practically confined to Europe and North America. This has accordingly been done. Europe and North America are the manufacturers for the whole world; and, if the extent of their work can be gauged, an idea is really given of the entire trade. The subject resolves itself into an inquiry, first, of the home production of these two continents, and then of their imports, the two together giving the measure of the world. Expressed in millions of pounds' weight we find,—

	1875.	1876.
The home-production of Europe and North America -	830	798
The imports into North America - - -	619	419
	1,442	1,217

1,449 million pounds then represent the whole supply; and of this total about 57 per cent. were of European and North American home growth, and about 43 per cent. imported. Apportioning this huge quantity, we find that no less than 351 million pounds, or very nearly a quarter of the whole, fall to the share of the British industry alone; the rest of Europe takes 844 million pounds, or 58 per cent.; North America, 254 million pounds, or 17½ per cent. In 1866, the total consumption of raw wool was 1,217 million, against 1,449 million pounds in 1875, and the average annual increase was consequently about 2 per cent. Of this about 1 per cent. was directly owing to the increase of population, which in Europe and North America rose from 321 to 347 millions in the stated period, the remaining 1 per cent. being due to the employment of wool for new purposes, and to the spread of comfort and wealth generally. Calculated per head of population, the consumption of raw wool, in 1875, was $4\frac{18}{100}$ pounds, or, taking the wool in its cleaned state, $2\frac{33}{100}$ pounds.

"It need not be said that all these figures pretend to no accuracy, but are open to correction; all they lay claim to is this, that, wherever possible, they are based upon the latest authentic returns, and that, where such basis was wanting, the estimates have been made with care and with a full consideration of all points involved."

Estimate of the Number of Sheep in the World.

	Year of Return.	No. of Sheep.
United Kingdom - - - -	1876	32,252,579
Russia - - - -	1870	48,132,000
Sweden - - - -	1873	1,695,434
Norway - - - -	1865	1,705,394
Denmark - - - -	1871	1,842,481
Iceland - - - -	—	800,000
Germany - - - -	1873	24,999,406
Austria - - - -	1871	20,103,395
Switzerland - - -	1866	447,001
Holland - - - -	1873	901,515

	Year of Return.	No. of Sheep.
Belgium	1866	586,097
France	1872	24,589,647
Italy	1874	6,977,104
Spain	1865	22,054,967
Portugal	1870	2,706,777
Total Europe (excluding Turkey and Greece), about		190,000,000
Australasia	1875	62,000,000
Cape	Estimate	16,000,000
Mexico	„	16,000,000
River Plate	„	60,000,000
North America	„	50,000,000
Remainder of America	„	6,000,000
Total		384,000,000
Turkey, North Africa, Persia, &c., say		65,000,000
India and China, say		35,000,000
Grand Total		484,000,000

Consumption of Wool.

It will be observed that in the following tables the production and consumption of the United States are included in that of North America. In order to bring our own consumption into more distinct relief, the writer has requested Mr. George W. Bond to estimate the consumption of wool *per capita* in the United States, as compared with that of Great Britain, and has been favoured with a reply. Deeming it unnecessary to confuse the reader with a statement of the complicated calculations by which Mr. Bond formed his estimate, we give simply the results. Of domestic wool and that imported, either in the form of wool or fabrics, the average consumption of the people of Great Britain is set down at three and two-thirds pounds of clean wool per person. The consumption of clean wool in the United States is set down at four and a third pounds per head. Although the tables which follow may surprise enthusiasts, by showing how gradually the consumption of the raw material of the wool manufacture of the civilised nations increases, it being at the rate of but about two per cent. for each year of this last decade, they show progress and stability of progress. They show that wool is holding, and likely to hold, its place among the few great national staples which make up the bulk of commercial commodities; and that a great step towards commercial and industrial independence is made by the nation which has planted a prosperous sheep-husbandry upon her soil.

Consumption of Raw Wool in Europe and North America.

In Millions of Pounds Weight (thus 247·7 = 247,700,000 lbs.).

Production of Europe and North America.	1875. Million Pounds.	1874. Million Pounds.	1873. Million Pounds.	1872. Million Pounds.	1871. Million Pounds.	1870. Million Pounds.	1869. Million Pounds.	1868. Million Pounds.	1867. Million Pounds.	1866. Million Pounds.
United Kingdom	162	167	165	156	152	158	165	172	163	145
Continent	462	464	473	475	480	485	490	495	501	504
British North America	13	13	13	13	13	13	12	12	12	12
United States	193	178	175	160	146	163	162	177	160	137
Total Product	830	822	826	804	791	819	829	856	836	798
Imports into Europe and North America.										
From Australasia	247·7	229	192·6	185·2	183·1	175·1	158·6	155·7	133·5	114·6
„ Cape of Good Hope	50·6	48·7	48·6	58·1	52	42·8	41·8	39·3	38·6	38
„ River Plate	207·9	208·5	230·7	212	198·7	185·2	205·6	198·8	171·8	157·2
„ West Coast of South America	7·7	7·5	7·6	10·4	8·1	7	8	9	11·6	8·6
„ Turkey and North Africa	66·6	60·6	70·4	86·4	70·1	38·2	44	52·1	51·5	62·4
„ East India	22·8	19·2	19·3	18·9	19·7	11·3	18·8	17·6	15·3	26·3
„ other Countries	4·8	5·3	4·3	5·7	5·7	5·8	5·3	5	4·1	3·9
Imports of Alpaca	4·2	4·2	4·4	3·8	3·6	3·9	3·3	1·8	3·5	3·6
„ „ Mohair	6·8	8	6·3	6·5	8·7	3·1	4·5	7	2·7	4·4
Total Imports	619·1	591	584·7	587	549·7	472·4	489·9	486·3	432·6	419
Production of Europe and North America	830	822	826	804	791	819	829	856	836	798
Imports „ „	619·1	591	584·7	587	549·7	472·4	489·9	486·3	432·6	419
Grand Total	1,449·1	1,413	1,410·7	1,391	1,340·7	1,291·4	1,318·9	1,342·3	1,268·6	1,217
Consumption of United Kingdom	351·3	363·6	358·5	324·1	336·7	322·7	299	317·2	299·6	312·5
„ „ Continent	843·7	812·3	816·7	793·9	763	762·2	801·2	811·1	763·7	696·5
„ „ North America	254·1	237·1	235·5	273	241	206·5	218·7	214	205·3	208
Total Consumption of Raw Wool	1,449·1	1,413	1,410·7	1,391	1,340·7	1,291·4	1,318·9	1,342·3	1,268·6	1,217
Estimated yield of Clean Wool after Washing	816·2	799·3	794·3	784·2	761·1	733·8	746·4	761·3	724·4	699·2

CONSUMPTION OF RAW WOOL IN EUROPE AND NORTH AMERICA.—*continued.*

	1875.	1874.	1873.	1872.	1871.	1870.	1869.	1868.	1867.	1866.
	Percentage of Total Consumption.	Percentage of Total Consumption.	Percentage of Total Consumption.	Percentage of Total Consumption.	Percentage of Total Consumption.	Percentage of Total Consumption.	Percentage of Total Consumption.	Percentage of Total Consumption.	Percentage of Total Consumption.	Percentage of Total Consumption.
Production of Europe and North America - -	57·3	58·2	58·6	57·8	59	63·4	62·8	63·8	65·9	65·5
Imports into „ „ „ - - -	42·7	41·8	41·4	42·2	41	36·6	37·2	36·2	34·1	34·5
	100	100	100	100	100	100	100	100	100	100
Consumption of United Kingdom - - -	24·2	25·7	25·4	23·3	25·1	25	22·7	23·6	23·6	25·7
„ Continent - - - -	58·2	57·5	57·9	57·1	56·9	59	60·7	60·5	60·2	57·2
„ North America - - - -	17·6	16·8	16·7	19·6	18	16	16·6	15·9	16·2	17·1
	100	100	100	100	100	100	100	100	100	100
	Millions of People.	Millions of People.	Millions of People.	Millions of People.	Millions of People.	Millions of People.	Millions of People.	Millions of People.	Millions of People.	Millions of People.
Estimated Population of Europe and North America -	347	344	341	338	335	333	330	327	324	321
	Pounds of Wool.	Pounds of Wool.	Pounds of Wool.	Pounds of Wool.	Pounds of Wool.	Pounds of Wool.	Pounds of Wool.	Pounds of Wool.	Pounds of Wool.	Pounds of Wool.
Consumption of Raw Wool per head of Population -	4·18	4·11	4·14	4·11	4	3·88	4	4·10	3·91	3·89
„ Clean Wool per head of Population -	2·35	2·32	2·33	2·32	2·27	2·20	2·26	2·33	2·23	2·18

NOTE.—All figures relating to Europe in these Tables exclude Turkey and Greece.

Wool Fabrics.

Class 235.—*Card-Wool Fabrics,—Yarns, Broadcloth, Doeskins, Fancy Cassimeres, Felted Goods, Hat Bodies.*

In considering the different classes of the manufactured products of wool at the Exhibition, it would be convenient, if not impracticable, to observe the geographical arrangement pursued in discussing the raw material. The peculiar national distinctions are less marked than in the raw material, and the products of some countries exhibit nothing calling for particular remark. It would be interesting to give the statistics of production of the different countries exhibiting, but these were not obtainable from any sources at our command.

The fabrics of the class now under consideration, with the exception of yarns and hat bodies, may be properly designated as "cloths." The most marked impression made by an examination in detail of the cloths of different countries was the cosmopolitan character of the cloths of all manufacturing nations. Although there are marked distinctions in the kinds of cloths, these seem to bear the impress of the time, or the fashion of the time, rather than of the country of fabrication.

This is especially true of the great mass of cloths for general consumption, which can scarcely be distinguished except by the degrees of perfection in their fabrication. It has been remarked that woollen cloths, by their universal use, have tended to obliterate the outward social distinctions of classes. It was observable at the Exhibition that they served to obscure the distinction of nationalities. This uniformity may be partially due to the supremacy of fashion, made more universal by modern facilities of communication, but equally to the identity of modern machinery, and the influence of the raw material upon manufactures.

In the last and in the early part of the present century, scarcely any fabrics were known under the designation of "cloths," except broadcloths, and twilled fabrics similar in face to broadcloths, called "cassimeres." Each piece was uniform in colour. Variety of colour and shade was the only element which the manufacturers had at command to satisfy the taste for change or the caprice of fashion. The principal distinctions were in the fineness and perfection of finish.

From the descriptions which remain of the methods of weaving broadcloths in the French convents during the fourteenth century, this fabric would appear to be now substantially the same made four centuries ago. The only change is in the fineness of the wools used, and the perfection of the face of the goods, due to better processes of shearing and pressing. This fabric will doubtless always occupy the first rank among woollen tissues. In this typical product of the woollen manufacture, the broadcloths from the West of England still occupy the eminent position accorded to them in all other International Exhibitions. The thickness and solidity of these cloths were not less conspicuous than their fineness and beautiful face. This was especially noticeable in the scarlet military cloths. All these cloths bear the designation of *Electoral*. signifying the kind of wool of which they are made; and, in fact, they are made of the highest-priced Silesian wool. The prices at which they were marked corresponded with their quality. The contrast of these goods with certain others made in England for export was remarkable. These fabrics are made chiefly for home consumption by the wealthy classes. For the class of consumers who use these goods, the competition among the manufacturers is in excellence rather than in cheapness. But the Judges had the proof within their own group that the skill required to produce these fine cloths is not an exclusive monopoly. One of our colleagues, Mr. Lang, who commenced the manufacture of broadcloths in 1814, exhibited, though not for competition, samples of blue and black broadcloths, made in 1853, at Vassalboro', Maine. The wool was selected Silesian, costing, with duties and charges, about three dollars per pound. The cloth had one hundred and twenty picks to the inch. The cloth, in fineness and perfection of finish, was admitted to surpass even the West of England broadcloth.

The comparatively low position of the United States in the manufacture of *fine* broadcloths cannot be denied. It was manifested by the absence of any notable exhibits, except by a single establishment, the Burlington Mills, of

Vermont. Their exhibits showed that our apparent inferiority in this manufacture was not due to any want of skill or capacity, but to other causes. This mill produces annually $300,000 in value of broadcloth, and it is known that another mill in Massachusetts, which did not exhibit, has shown equal proofs of its skill in this manufacture. The products of the mill first referred to would undoubtedly suffer in comparison with the West of England standards, for the goods, beautiful in face and fineness, were lacking in weight. But they were intentionally made to conform to the prevailing fashion of the higher standard of the German light-weight goods, with which they bore a favourable comparison. It would be erroneous to make the position of the broadcloth industry a reproach against the American woollen manufacturer. The same apparent decline, though perhaps not in the same degree, is witnessed in most other manufacturing nations. Superfine broadcloths are now used only by a limited class, and by that class rarely, except for dress coats, which last for years. The coats are made by fashionable tailors, who, as a rule, prefer foreign cloths. As the fine cloths are principally used by the easy classes, the duties upon the fine foreign cloths are no impediment to their consumption, while the specific or weight duty is less onerous upon them than upon common cloths.

The capacity to manufacture the finest broadcloths in this country was proved, many years ago, by the celebrated Middlesex Mills of Lowell, Massachusetts,—in age, influence, and continuity of excellence standing at the very front of our cloth-mills. In ceasing to give prominence to the fine broadcloth manufacture, it has manifested no failure in skill, but simply an adaptation to the wants of the times.

The diminution in the American manufacture of fine broadcloths has been attributed to the effect of the tariff of 1846. It has also been materially influenced by the constantly diminishing domestic supply of superfine wools, the Saxon wool-culture, as we have seen, having nearly ceased; for it is well established that an abundant domestic supply of raw material is one of the most potent of the influences which give a special character to the manufactures of a country. But the principal cause of the decline referred to is the popular demand for other fabrics, hereafter more fully referred to. In a word, our manufacturers have ceased, as a rule, to make fine broadcloths, because they find ample and more profitable employment for their looms in the production of the lower cloths which enter into general consumption. It has been observed that a similar decline, or more strictly speaking, diminution, of the fine-cloth manufacture is observed in other countries. Although a few excellent broad cloths and satins, or doeskins of remarkable beauty, were exhibited by Belgium and Germany, the Judges of large experience in dealing with woollen fabrics failed to find, in the exhibits of Belgium and especially of Germany, that competition for excellence in the production of superfine cloths which they had been led to expect from the former reputation of Belgian and German manufacturers. In the production of plain-faced goods of a lower grade, adapted for special uses,—such as blue and gray uniforms for soldiers, police officers, newsboys, and watchmen,—there were evidences of much progress, both in fabrication and cheapness, on the part of American manufacturers. Our regular soldiers, wearing American fabrics, are declared by our army authorities to be better clothed than any in the world. The beauty of the uniforms of our volunteer troops, many thousands of whom were in procession on the Centennial Fourth of July, was specially noted by the foreign Judges. The production of blue police cloths has become an extensive branch of our manufacture, and the cloths are marked for their cheapness, durability of dye, and solidity of fabric.

The period of 1836 was an epoch in the cloth industry of the world and of the century. It was the commencement of the change which has produced a character of the cloth fabrics, for general consumption throughout the world, which was one of the most conspicuous features of the Exhibition.

In 1834, M. Bonjean, a prominent wool-manufacturer in Sedan, France, and an *élève* of the Polytechnic School, conceived the idea of modifying the plain cloths hitherto universally made, by uniting upon the same stuff different tints or patterns of tissue. This he was able to effect by the Jacquard loom. It was evident that the variety of stuffs which could be thus made was as unlimited as fancy. Hence he styled his woollens fancy cassimeres. These cloths, put on the market, and displayed at public exhibitions, instantly struck the popular

taste, and were imitated, at first in France, and then in all other manufacturing nations. Their introduction into this country is an illustration of the benefits flowing from National Exhibitions. In 1840 an American gentleman, arriving directly from Paris, visited Mr. Samuel Lawrence, then agent of the Middlesex Mills at Lowell, Massachusetts. In the words of Mr. Lawrence, "He had an "overcoat woven in diamond figures, of great beauty; said he saw it at an "Exhibition at Paris; Bonjean and Son, of Sedan, were the manufacturers. "He gave me a small bit from the inside of the collar." With this bit as an example of what was to be done, Mr. Lawrence applied to Mr. George Crompton to adapt machinery for this tissue, already devised in cotton fabrics; and the result was the invention of the Crompton loom, upon which fancy cassimeres have since been woven, not only in this country, but in Sweden, Germany, Austria, and Belgium. From this statement, it would seem that fancy cassimeres were first made in this country at Lowell. But it should be observed that the honour of the first introduction is also claimed by the New England Mills of Rockville, Connecticut. The new cloths were adapted to the natural change which had begun to take place in the culture of wools. They required soundness, length, and strength, rather than the softness and fineness which had been the essential qualities of clothing-wools. The more abundant supply of the intermediary wools has continued to favour the production of the fancy woven cloths; and from their great predominance at the Exhibition, and in the business suits commonly worn, it would seem that they comprise from three-quarters to nine-tenths of all the cloths made at the present day.

In the class of fancy woven cloths,—including not only fancy cassimeres, but cloths for overcoatings and worsted coatings,—the manufacturers of Elbeuf and Sedan sustained at the Exhibition their long-established reputation for novelty of design and perfection of fabrication; and Belgium was not far behind. The fine and thin cassimeres of Belgium, called "Batistes," made for consumption in tropical countries in the place of cotton and linen fabrics, were conspicuous for their beauty. Among the British exhibits,—besides some fancy cloths exhibited by West of England manufacturers, woven by a novel process analogous to knitting,—certain solid and substantial fancy cloths, made in Ireland, of Cheviot wool, with double and twisted yarns, received special commendation, and are worthy of imitation here.

The writer may be permitted to speak of the admiration and surprise expressed by the foreign Judges of this group, at the first inspection of the American fancy cassimeres. The goods of our exhibitors, it may be remarked, were arranged with good taste, in costly but not obtrusive cases, which served to enhance their favourable impression. The Swedish Judge, Mr. Carl Arnberg, a practical wool-manufacturer of large observation, will pardon the repetition of his precise language addressed to the writer: "You know that the best "fancy cassimeres in the world have been made at Sedan and Elbeuf in France. "If these goods were placed by the side of the Elbeuf cassimeres, you could "not tell one from the other, and the goods could not be bought at Elbeuf for "the prices marked here." It was conceded by all the Judges that our fancy cassimeres, in material, fabrication, and design, had attained the highest standard of this fabric. No single mill or State could claim the palm; for the honours were divided between a mill in Utica, New York, one in Pittsfield, Massachusetts, and three mills in Rockville, Connecticut, while other mills so nearly approached them as to make their special mention almost invidious. This favourable impression of our foreign associates was confirmed by visits which they made to some of the mills which had exhibited. They shared the opinion expressed to the writer by Professor Grothe, of Germany, author of the most complete modern treatise on the card-wool manufacture, that the American mills which he had just visited were in possession of the best and most recent processes, improvements, and machines known in Europe, and were admirable in their administration. It is due to our wool-growers to say that the cloths so highly commended were made generally of American wool, Australian wool being used in some cases, not from preference, but to eke out the short supply of the domestic stock.

It is proper in this connection to depart from the strict arrangement of the classification to consider a class of fabrics which, though made of combed wool, are really cloths, and are directly allied with the card-wool fabrics just reviewed. The Exhibition showed that the most formidable rivals of the fancy

cassimeres are the fabrics known as worsted coatings. Being woven in the fancy loom, either Jacquard or Crompton, and made for the same purposes and by the same manufacturers as the cassimeres, they differ from them only in the respect that the cassimeres are made of carded and the worsted cloth of combed wool. This fabric, created in France, in the introduction of its fabrication to this country affords another illustration of the benefit of International Exhibitions. Mr. E. R. Mudge, of Boston, being Commissioner of the United States at the Exposition of Paris of 1867, was impressed with this fabric then exhibited, and then much worn both in London and Paris, as a novelty. Seeing that it was made of combed Merino wool, he directed inquiries to ascertain if suitable wools for this fabric could be abundantly furnished by American fleeces. Satisfying himself affirmatively upon this point, he imported and introduced the requisite machinery for combing and spinning the wools at the Washington Mills, in Lawrence, Massachusetts, of which he is a leading director. This establishment succeeded so well in the fabrication of these stuffs, and they proved so popular when thrown upon the market, that the introducer soon found a host of rivals and imitators. A new industry at once sprung up,—that of combing and spinning the wools into worsted yarns, for supplying the many fancy cassimere-mills which desired to weave these fabrics. One of the most conspicuous displays at the Exhibition was that of the United Spinners' Association of Philadelphia, comprising eight distinct establishments, all exclusively devoted to making Merino combing-wool worsteds for worsted coatings and for suspenders and india-rubber goods, and producing an annual product of $1,500,000. The perfection of the yarns was fully recognised by the experts in the group of Judges. They were made almost exclusively of American Merino wool, which the exhibitors declared to have proved preferable for their purpose to even the best Australian wools, being "kinder, more elastic, and stronger." Here was a new industry founded scarcely six years ago, and a palpable demonstration of new and unsuspected qualities of excellence in American wools,—a demonstration most gratifying to those who, twelve years ago, had pointed out these qualities to incredulous manufacturers.

The American worsted coatings were extensively exhibited. The excellence attained in so short a period was a matter of surprise. While the fine diagonals of Sedan were not equalled, the American exhibit, as a whole, compared favourably with those from abroad. In the fabrics for overcoatings, Moscows, Kerseys, Castor beavers, and Elysians, there was the same general resemblance in the stuffs from different countries, already spoken of as forming one of the characteristic features of the woollen manufacture of the present day. All the kinds made abroad, with the exception of special novelties,—like the beautiful *peau d'ours*, a species of Moscow coating made at Dussen, in Germany, and the delicately soft Montagnac overcoatings of Sedan,—are made in this country; and our fabrics did not suffer by comparison.

The value of a manufacture is shown less in costly fabrics than in the common cloths combining utility and cheapness. Commendation was given to a mill established as an accessory to the largest iron-making establishment in Pennsylvania, in which the women and children of the operatives obtained employment, and which furnished cloths, marked for their soundness and cheapness, for the workmen. Many of the combinations of wool with cotton or union cloths were noticeable for cheapness and utility, such as the Kentucky jeans with cotton warps and wool filling, in much esteem for cheapness and wearing qualities in the agricultural districts in the Southern and Western States. The repellents, or water-proof cloths, show another union fabric.

Felted Goods.

The exhibits of felted goods, quite numerous and varied from the United States, were few and barely incidental from foreign nations; and those which were seen were Oriental in their origin or affinities. They were incidentally seen in the national fez of Turkey, so enduring in fabric and pleasing as well as enduring in its madder-red colour; in *fils* of exquisite softness to the touch, made of camel's hair, forming the ground for costly Turkish embroidery (a material deserving more extensive use for this purpose); and the thick Russian felts made up into boots and gaiters,—the only foot-covering, according to Mr. Bielsky, the Commissioner for Russia, capable of resisting the cold of a Siberian winter. These articles also deserve imitation. It is believed that

felted cloth was the most natural and the first stuff employed by man. We cannot reflect without pride that the first invention of primitive man in the textile arts, originating in Asia, the cradle of the race, and still in use among the ruder tribes of the East, remained without progress for centuries, until revised, amplified, and made tributary to domestic comfort and the arts in all civilized communities, by our own countrymen and in our own times. M. Kœppelin, a French expert, speaks thus, in the *Annales du Genie Civil* of 1869, of this fabric: "In spite of the simplicity of its fabrication, and in spite "of the antiquity of its origin, felting was for a long time abandoned to the "lesser industries. It is only within thirty years that the mechanical fabrica- "tion of felted cloths has been essayed. Many fruitless attempts in this "direction were made in France and other countries; and it is only to the "spirit of invention of two Americans, Wells and Williams, that we owe the "processes now in use, and which have not been materially modified since the "epoch of their discovery." Their processes, he says, were applied in France and England, and are used in the latter country for making printed felt carpets, exported in vast quantities to all parts of the world, and popular from their great cheapness.

No other published notice of this interesting invention has come within the notice of the writer. He has fortunately come into possession of other facts in relation to the introduction of this important fabric, creditable alike to American ingenuity and British enterprise, which seem worthy of a detailed notice, because not hitherto known to the public. The facts are derived from a personal communication by a gentleman hereafter mentioned.

Thomas Robinson Williams, of Newport, Rhode Island, connected with the Hazard family of that State, so well known as wool-manufacturers, invented the process of making felt cloth of commercial length, at Rhode Island, about 1820. About 1824, he went to England for the purpose of introducing this invention, and also one for making hat bodies, in which he was associated with a Mr. Wells. He took out a patent in England in 1830. He succeeded in enlisting the co-operation of capitalists, who, about 1838, erected a factory in Leeds, with a capital and plant of 250,000*l.*, the designation of the proprietors being the Victoria Cloth Company. Meeting with immediate success in the fabrication, the enterprise created a great excitement in manufacturing circles, as it threatened to revolutionise the whole system of cloth-making. The principal editors of the London papers visited the establishment, and vied with each other in descriptions of the new art. The Queen gave extensive orders for the stuffs, and the Mistress of the Robes—the Duchess of Sutherland—furnished the grand staircase and vestibule of her London residence with a crimson carpet of the Williams felting, draping the windows of the hall with a thinner fabric of the same make. In the full tide of its success, the vast establishment was destroyed by an incendiary fire. It was uninsured; and Williams, whose whole property was in it, died from grief and disappointment. In the mean time, a patent for making felt cloths of a commercial length, by an entirely dissimilar process, had been taken out by Joseph Waite, of Leeds, the use of which in England was prohibited by the courts, as conflicting with Williams's patent. Mr. J. Burrows Hyde, of New York, our informant as to these facts, a gentleman of science and enterprise, bought both the Waite patent and the Williams patent in this country, and sold the rights to the Bay State (now Washington) Mills, at Lawrence, Massachusetts, about 1853. For many years this mill enjoyed nearly the complete monopoly of this fabrication in this country, to its great profit. The exceptions to this monopoly were a fabrication of felt cloths, not of commercial lengths, conducted in Norwalk, Connecticut, under the Bishop patent, and the manufacture of hat bodies, conducted under the Wells patents. The Williams and Waite patents having expired in Europe and this country, the manufacture has attained the wide and vast extension of the present day.

While few foreign exhibits of this fabric were noted, the American felts appeared in innumerable forms. They appeared as printed and embossed piano-cloths, and as ladies' skirts; as floor-cloths printed by a Philadelphia establishment, with highly artistic designs; as a material for sheathing roofs, vessels, and iron buildings; combined with asbestos, as non-conducting envelopes for steam-boilers and hot-air pipes; for lining rubber fabrics (being the only material which stretches equally in all directions); in soles for shoes

and in gun-wads, in masses of several inches in thickness, for polishing wheels and buffers for jewelers; in other forms, for polishing cabinet-work and marble; and, in a high-cost material, for hammers of piano-keys. Conspicuous among these exhibits were the felts for polishing, made by Charles N. Bacon, of Winchester, Massachusetts, which possessed a thickness, compactness, and adaptation to special purposes which have never been surpassed. In the common felts the raw material is hair, or the cheapest Mexican wool, and in the others, as before said, the finest wool from Silesia. These were interesting illustrations of the almost infinite uses which may be derived from a single attribute of a fibre, all resulting from the serratures in the filament of wool and hair, which give them their felting power.

Allied to these goods, though not strictly felts, are the feltings used in paper-making, which are woven fabrics highly felted. The enormous extension of our paper-manufacture has of late years stimulated a supply from domestic sources of this indispensable material for paper-making, not long since obtained from abroad. Exhibits of paper felts were made by several mills. A letter from Messrs. Rice, Kendall, & Co., paper-manufacturers and dealers in paper-makers' supplies,—the head of the firm being the present Governor of Massachusetts,—expresses the general character of the American felts, although having in view the product of a special mill. "We have introduced them," they say, "into paper-mills making all the finer qualities of bond- or writing-" paper; also best and ordinary book-, news-, Manila-, tissue-, straw-, and " sheathing-paper; also printers' and woollen manufacturers' press-boards, " leathers, and binders' boards, and wood-pulp; and have had many recom-" mendations from the manufacturers regarding their wear and suitable " quality . . . . We feel confident that they (the American felt-makers " named) are able to manufacture anything in the line of feltings used by the " various manufacturers of paper; and, judging from our former experience as " importers of felts, they have made many improvements in them." It is curious that the art of joining the two extremities to make an endless felt is kept a secret by the fortunate possessors, for the use of which manufacturers pay a royalty.

Although no hat bodies—another form of felted goods—were exhibited, several special machines for forming hat bodies were shown, illustrating how completely the handicraft had been substituted by machinery. There is hardly a process in the manufacture which is not now done automatically, a single establishment turning off eight hundred dozen of hats daily. The hatter, as a separate artisan, has disappeared. Fifty years ago there was one in every village. A hatter's bow having been recently required in a patent trial, a diligent search could not find one in the country.

Class 236.—*Plain Flannels, Dometts, Opera and Fancy.*

The flannel-manufacture, almost exclusively represented at the Exhibition by American exhibits, has attained an enormous development in the United States, as illustrated by the fact that an auction sale, in July last, by a single house representing 157 sets in different mills, netted $2,500,000. Flannel being the first stage is the manufacture of plain cloth, it constitutes one of the principal products of the smaller mills in the new States; while, in the older manufacturing States, mills employing from ten to fifty sets are exclusively engaged in its manufacture. The great domestic demand for these goods may be attributed to the rigour of our climate, or to the fact that the masses of our population are liberal in providing themselves with the fabric so essential for personal comfort. Flannels find their consumption not only in men's garments,—for which purpose their use has vastly increased through better hygienic knowledge,—but in garments for children, linings for over coats, blouses for workmen, fatigue uniforms for soldiers and police officers, and coats for summer wear.

It is some twenty or thirty years since the American fabric excluded foreign flannels from our market, with the single exception of opera flannels, which no longer exist. The primary cause of the success in this manufacture has been the peculiar adaptation of American wools for this fabric. This adaptation consists in their spinning qualities, their soundness and elasticity, and the medium fineness, producing the requisite softness, without too much felting quality to cause an undue shrinkage of the goods.

By an examination of a line or series of samples of different grades of English flannels, in comparison with a line of American flannels corresponding in grade and price, it was observed that the English flannels are more highly fulled, and less finished in the face, than the American goods. The American fabrics have the yarns more closely twisted, in order to prevent shrinkage, and the fabric is smoother and more sightly in face. The difference in intrinsic value could not be proven, the different styles being adapted to the tastes of different markets. A large exportation is now being made to Canada.

With the command of their own markets, American manufacturers have adapted their fabrics to the wants of consumers. In 1835 the domett flannels, an original fabric composed of a cotton warp with a filling of wool, came into use as a substitute for the linsey-woollen stuffs, originally of household manufacture, worn by working women for under-petticoats. Having the merit of shrinking but little in washing, it still holds its place as a characteristic American fabric. The red flannels have found a vast consumption among the working population, especially lumbermen and frontiersmen, the pliability of the fabric giving freedom to the limbs. Formerly the red colour, less brilliant than now used, was given by a madder dye, subsequently by *lac;* while at present the brilliant and fast scarlet of the cochineal is in almost universal use, the price of cochineal having been reduced to half of its former rate by the introduction of the aniline dyes. The consumption of blue flannels by the army and navy forms another important outlet for this class of fabrics. They form the undergarments for all the men in both services, and the summer undress coats in the former. The regulations of the services require that these flannels should have a twilled weave, and be both wool- and indigo-dyed. The regulations of the Government have tended to keep alive the skill in indigo-dyeing, which, from its costliness, threatened to disappear before cheaper processes. The excellence attained in the army and navy flannels led the way to a more perfected fabric. About 1859 appeared, either through the Middlesex or Washington Mills,—for the honour is claimed by both, and the products of both vie with each other in celebrity,—the blue flannel coating, indigo- and wool-dyed, and having a three-leaved twill. This fabric—sheared and finished like cloth, but retaining the lightness and pliability of the flannel texture, forming an admirable material for summer garments—is distinctly American in origin and character. It has a large domestic consumption, and has become an article of export to South America.

Opera flannels—a name given abroad, from one of its original uses, to a light flannel more highly gigged and finished than the ordinary article, being piece-dyed uniformly, in many fancy colours, and hot-pressed—were first introduced into this country by the Bay State Mills. They have, however, gained their command of the American market principally through the fabrication of a manufacturer of Ware, Massachusetts, now deceased. He commenced the manufacture in 1858, making in that year four thousand pieces. In 1871 his establishment made and sold, of this single fabric, one hundred and twenty thousand pieces, or nearly two million yards. At this time foreign importations of this fabric had entirely ceased. The thorough cleansing of the fabric to receive the dye, and the requisite skill to give the numerous colours and shades desired, are the principal difficulties which the manufacturers have to encounter, single manufacturers keeping all the time a hundred or more distinct shades and colours in stock. American opera flannels were abundantly and tastefully displayed at the Exhibition by several mills. Nothing surpassed them in variety and perfection of hues and shades, except, perhaps, the masterpieces of the French dye-houses.—the exquisite merinos of Rheims and Paris. It is noteworthy that these fabrics are made wholly of American wool, the quality known as XX being used for medium, and picklock (selected from choice flocks) for the finest grades.

American flannels of a still higher grade exhibited were the all-wool gauze and silk-warped flannels. The credit of the introduction of the fine flannel manufacture belongs to the Ballardvale Mills, in Andover, Massachusetts, this mill being the first which made fine yarns by double spinning. In some of these fabrics, made expressly for the Exhibition, there were one hundred and thirty picks to the inch. The yarns for filling were spun in such fineness that they attained 46,500 yards in length to the pound, the warps reaching 34,500 yards. Among the uses of these fine flannels is their application for lining

coffins and for burial shrouds. It is known that the wealthy classes in England, in the last century, rebelled against a law requiring all persons to be buried in flannels. Improvements in manufacture have caused a fabric, which was then obnoxious from its coarseness, to be now specially adapted for burial habiliments, through its softness and fineness.

Another variety of flannel, which has wholly replaced the French fabric formerly largely imported, is the fancy flannel still called French plaid. The fabrics of this variety consist of plaids, or broken plaids and checks, and are dyed in the wool. The great bulk consists of two colours combined, scarlet and white and blue and white. They are largely used for shirts and children's garments. The printed flannels for children, formerly in use, have almost wholly disappeared.

Class 237.—*Blankets, Robes, and Shawls.*

The last observation made under the preceding class also applies to the first article in this class. The American medium or grade merino wools are no less fitted for flannels than for blankets. They compose the raw material of the great bulk of the blankets which enter into our consumption, although noils, from carpet- and combing-wools, are used to some extent. The lowest grades of blankets, composed of shoddy, hair, and the cheapest wool, which are saleable abroad, cannot be disposed of here. Even the lowest of our consumers, the savage Indians,—who are supplied with blankets by our Government, according to the statement of one of our colleagues, who is a member of the Indian Peace Commission,—are skilful judges of the quality of blankets. The standard Indian blankets shown at the Exhibition presented all the requisites of a substantial and useful article.

Many mills are exclusively devoted to the production of blankets, principally those of medium qualities for the consumption of the millions. Some Eastern manufacturers, who have made blankets for forty years, have a yearly production exceeding $1,000,000 in value, and one establishment in Minnesota a production of nearly $400,000 annually. The substantial quality of these medium goods, and in some the cleanness of the stock and freedom from grease, were especially noticeable.

No wool fabrics at the Exhibition, of our own production, attracted so much admiration from the foreign Judges as the highest grades of American blankets. The credit of the introduction of this eminently characteristic fabric is due to the Mission Mills of California, established in 1858. Nothing comparable with these blankets in weight, thickness, softness, and perfection of face had ever before been attempted, and it is impossible to conceive of a more luxurious bed-covering. The beauty of the fabric was not less a matter of surprise to our foreign visitors than the luxurious tastes of a people which could make blankets costing from thirty to fifty dollars a pair saleable. The California blankets of this grade are made with a filling of Australian wool, the warps being of California wool. Blankets of no less beauty and perfection were exhibited by a Minnesota mill, and these were made exclusively of wool grown in that State.

Totally different in style and material, but no less admirable, were blankets exhibited by Austria and the Netherlands. Those exhibited by a Netherlands manufacturer were especially noticeable. The wool was of a coarser quality than that used in the California blankets, and the pile of unusual length. They were woven in great variety of colours, and with tasteful designs, in the Jacquard loom, and are highly worthy of imitation by our manufacturers.

An ample field for the application of colour is found in the manufacture of rail-car blankets, and especially of carriage, railway, and lap robes. All the European styles of these articles have been adopted here, besides other articles of this class, of still more extensive use, such as the admirable horse-cloths and blankets not long since exclusively furnished by England, which find complete imitation, if not improvement, in our own manufactures.

In the important class of shawls, we naturally observe those most nearly allied in material and texture to the fabrics which we have been considering. The manufacture of the all-wool plaid shawls—formerly known in this country as the Bay State Shawl, from the mill which introduced it—originated in Massachusetts about 1848. Favoured by the easy application of the cassimere twill to this fabric, and the facility with which the design is made and varied through the alternate concurrence of the warp and woof, and still further

aided by the adaptation of medium American wools to this fabric, it at once attained perfection. The shawls of the Bay State Mills exhibited at the first International Exhibition, that of 1851, were pronounced by French experts as "quite remarkable for the lightness and softness of the stuff;" and shawls exhibited by the same mill at the Paris Exposition of 1867 were commended for the same qualities, as well as for their moderate price. This manufacture has now immense production. Still, the English and Scotch shawls, made of coarser Cheviot wools, and of a thicker texture, would be preferred for many uses.

No attempts to make the highest qualities of shawls have been made in this country, partly for the same reason that the French, who had perfectly succeeded in making the cashmere shawls, were compelled to abandon the manufacture, because the French ladies preferred an inferior but genuine Indian shawl to a better article of French fabrication. Exquisite shawls, but of precisely the same texture as the Indian shawls, were exhibited by Lyons manufacturers. The material is the finest and most costly Electoral wool. The prices range from $30 to $150. The only rivals of the French in this class of shawls are houses in Vienna, whose products were also exhibited. None but the initiated could determine the difference between these two national products. The French, however, assert that the Austrian products are copied from their own, but that the delicacy of the originals is lost, saying, "One may transplant a tree, but not the soil and the air which give flavour to its fruits." It is asserted that the silky Mauchamp wool, previously mentioned, forms a material for the finest shawls, really surpassing the cashmere of the East.

Admirable shawls made of wool or worsted, in India designs, have become celebrated under the name of Paisley shawls, from the place of their manufacture in Scotland. None of the Scotch shawls of this class were exhibited, but this style of fabrication was represented by shawls of India designs, made by Messrs. Martin Landenberger & Sons, of Philadelphia, the material being American combing-wool. These shawls, well made and in excellent taste, are woven in the power Jacquard loom, at prices so moderate as to insure a large popular consumption.

CLASS 238.—*Combed Wool Fabrics, Worsted, Yarns, Dress Goods for Women's Wear. Delaines, Serges, Poplins, Merinos.*

This class includes, with the exception of carpets, all the multitudinous fabrics recognised in England as the products of the worsted industry. It forms the second of the two grand divisions of the wool-industry. Through the variety of its products, the skill demanded in their fabrication, the capital and number of persons employed in the great manufacturing nations of Europe, and the rapidity of its development during the last century, this division has become the most important branch of the woollen manufacture.

So important a class could not fail to be largely represented in an exhibition of the products of the world; but the student of textile industry was obliged to regret an incompleteness in the series of these fabrics, especially from the two leading nations in this industry,—France and England,—and a deficiency in the labelling of many which were exhibited, so as to show their proper names and composition. We were disappointed in the expectation that the Exhibition would shed full light upon the difficult subject of the nomenclature and composition of the infinite variety of worsted fabrics. We use the word "worsted"—which, although not strictly accurate, is the most convenient English term—to designate the fabrics in question.

To render our future remarks intelligible to unskilled readers, we are compelled to enter at once upon the subject of the names and distinguishing characteristics of worsted fabrics, an inquiry demanded by the popular ignorance on the subject, which prevails to no little extent even among the dealers in the articles in question. In no department of practical knowledge is there so much confusion in the meaning and application of names. The names of the fabrics have rarely any etymological signification. They are usually given arbitrarily by the first introducer of the article, and, if they are successful, become applied to articles quite different from the original fabrics, and especially to imitations in cheaper materials. Fabrics substantially the same are constantly reappearing under different names. It is still possible,

though difficult, to obtain some order out of this apparent confusion, and to bring the different varieties of these fabrics into an arrangement which approaches a scientific classification.

The leading basis of this classification is the character of the weave, or, as it is styled by the French, the *armure* of the fabric, the word *armure* signifying the system of harnesses with which the loom is *armed*, or provided, to produce a definite issue. The *armures* consist of four fundamental or classical forms, from which all the varities of simple tissues are derived. 1. That of *taffeta*. In this, the most simple form of tissue, there are only two harnesses, forming a simple interlacement of the threads of the warp and weft. This is the weave of broadcloth, cotton shirtings and sheetings, and mousselines de laine. 2. The twilled or *Batavia* weave, produced by four harnesses. 3. The *serge* tissue, produced by three harnesses. 4. The *satin* weave, produced by five or more harnesses, the effect of which is to bring the threads of the weft to the face. Different effects are produced from derivatives of these fundamental tissues. Thus, in the most simple,—that of cloth or taffetas,—varied effects are produced by the greater or less torsion of the threads, and the direction in which they are twisted; by variations in the size of the threads of the warp or weft compared with each other; by making the same weft pass alternately over two threads and one thread of the warp, making a "rep" or corded tissue. Still other variations are made by the different materials of the warp and weft, by having them of pure wool and of a single colour, or mixed with silk, mohair, or China-grass, or by having the threads printed in different tints. The four fundamental regular interlacements before described, which form the base or ground of even the most complicated tissues, are further varied by having combinations of crossings of the threads which occur at variable places at each course of the thread across the web, forming figured, brocade, or damasked effects, which are produced by the Jacquard loom. Another variation is made by having two warps, one to form the ground of the tissue, and the other made to pass over wires to form a loop, making the velvet or pile fabrics. There are still to be added the highly-important differences of character, equally obvious to the touch and the eye, produced by the character of the wool used, whether fine and soft (like merino and cashmere), or hard and lustrous (like English combing-wool and mohair).

These remarks will enable the reader more readily to understand the classification of fabrics condensed from M. Alcan (the highest authority upon this subject), and published in his treatise on working wools, in 1866. As the American importation of worsted dress goods is principally from France, the catalogue is not less valuable because limited to French fabrics. For the same reason the French names are retained.

Worsted Stuffs of Fine Wool.

Names of Stuffs.	Armure.	Warp.	Weft.	Observations.
Manteau	Taffetas	Wool carded	Wool carded	
Reps	"	Wool	Fine wool	Made of long-combed wool, and wide for furniture.
Turquoise	Serge	"	Wool	Woven in checks and Scotch plaids, the warp having a serge armure of 2 and 1, and the weft a serge armure of 1 and 2.
Merinos	Batavia or twill on both sides	Fine wool	"	Made from 8 to 50 picks to the centimetre. Its use universal. Piece-dyed.
Cashmere	Twilled on one side	"	"	
Drap d'été	" "	"	"	The warp double.
Mousselines	Taffeta	"	"	
Moulletons	Satin	Wool	"	
Popeline or poplin		Various materials.	English wool	Poplins are either all wool, or with warps of cotton, silk chappe, or organzine, or fancy printed. The poplin or corded effect produced by the size of the weft.

Worsted Stuffs of Fine Wool.—*cont.*

Name of Stuffs.	Armure.	Warp.	Weft.	Observations.
Barége	Gauze or open taffeta	Cotton	English wool	Generally printed.
Challis	„ „	Silk grège	Merino wool	Differs from barége only in the materials.
Grenadine	„ „	Silk grège, organzine, or cotton.	English combing-wool.	The weft highly twisted and gas serged; a kind of close barége.
Mozambique	Gauze and taffeta	Cotton	„ „	
Crape of Spain	„ „	Silk grège	Merino wool	The same weave as the preceding, but differing in material.
Llanos	„ „	Cotton	Mohair, or mixed with silk.	The warp composed of three threads, and is white, while the weft is violet blue, or black, which gives reflections to the stuff.
Grisaille	Taffeta	Cotton chappe or fancy.	English	The warps are printed or *chinés*.
Toile de Saxe	„	Cotton, simple, or double and twisted.	„	Characterised by its pecular finish.
Circassianne	„	Silk grège	Mohair, or silk and mohair.	
Cretonne	„	Cotton, double and twisted.	Wool	The stuff has a peculiar elasticity, due to the close spinning of the warp.
Jupons	„	Simple cotton	Carded wool	
Vode	„	Wool		For religieuses.
Valencias	„	Silk chappe	Combed wool.	
Damask	Figured or fancy	Wool or silk	Wool	For furniture.
Bolivar	Taffeta	Wool	„	A light flannel, made in gray or in all varieties of colours.
Alpaga	„	Cotton	Lincoln wool.	
Popeline satin	„	Wool and silk grège.	Knit wool.	
Taffetas	„	Silk	Merino wool	
Biarets	Corded or cannel	Merino wool	„	
Epinglé	Taffeta and corded	„	„	
Alpine	Serge 2 and 1	Silk	„	
Drap d'Alpes	Serge	Fancy	„	
Anacosti	=	Wool	„	
Batavia	„	„	„	
Epengline	„	Silk	„	
Tamise reps	Corded	Wool	„	
Veloutine	„	Fancy	„	
Drap d'Alma	„	Wool	„	

There are no means of obtaining the names of other French fabrics, or the new names of the same fabrics introduced since the above list was published, except from the dealers in these articles. We have to thank Messrs. Hovey & Co., of Boston, for a series of samples of French fabrics, with the following names:

Velours	All wool.
Empress	All wool.
Chambery gauze	Silk and goat's hair.
Mousseline de bege	
Cashmere de bege	All wool.
Merino tulle	All wool.
Pongee	Silk and wool.
Mohair glacé	Goat's hair and cotton.
Vigogne	Silk and wool and all wool,
Serge	All wool.
Basket	All wool, fancy.
Matelasse	Silk and wool.
Diagonals	All wool and silk wool.
Imperial silk serge	Silk and wool.
Algerine	All wool.

Armure	Silk and wool.
Turenne cloth	Cotton and wool.
Drap d'Alma	Silk and wool.
Sicilienne	Silk and wool.
Bombazine	Silk and wool.
Tamise	All wool.
Chinchilla	Camel's hair.
Mexican cloth	Silk and wool.
Knickerbockers	Wool with irregular spots of different colours and materials.
French camel's hair	Cashmere goat's wool.
Satine	All wool, with satin weave.
Australian crape	Cotton and wool.
Drap de Nationelle	All wool.
Parametta cloth	Silk and wool.
Henrietta cloth	Silk and wool.
Hernani	Silk and wool.
Damasks, Brocades	Wool, silk and wool, and wool and cotton, in infinite varieties for furniture, woven on the Jacquard loom.

Some of the general features of the French fabrication of dress and furniture stuffs may here be appropriately considered. The influence of the possession by France of Merino wool upon the character of her dress fabrics has already been referred to in this report. In the spinning of fine Merino wools, and weaving them into dress goods, France takes precedence of all nations.

The most important contribution to this success was the invention, by Heilman, of Mulhouse, of a method of mechanical combing, adapted to the short fibres of Merino wool as well as to the long staple formerly regarded as exclusively combing-wool. Mainly through this invention, France, to use Mr. Alcan's words, "marched, in the early part of this century, with the step "of a giant. The means of fabrication were so ameliorated, in the short space "of a quarter of a century, that the spinning of Merino wools attained a fine-"ness and regularity once impossible with the best hand-spinning. The "machines turned out lengths of yarn of 200,000 metres to the kilogramme, "from a kind of wool which, twenty-five years before, would scarcely have "produced 50,000 metres; and the price of the unit of weight of an identical "article had descended from eighty to fourteen francs, although the prices of "labour had increased." Among the exhibits of the house of Auguste Seydoux, illustrating the material from which their famous merinos, cashmeres, and challis are made, were weft yarns of Australian combed wool of the fineness of 109,120 yards to one pound. It is unnecessary to enlarge upon the beauty and perfection of the merinos, cashmeres d'Ecosse, and challis exhibited at Philadelphia. They are recognised throughout the world as inimitable, and as exhibiting the most perfect fabrics in the whole range of the textile industry.

Another reason for the French success in these fabrics is the specialization of different branches, and the fabrication of the same article, the spinning, weaving, and finishing forming the three great groups. The division of the fabrication into groups, according to Alcan, "facilitates the labour, concentrates "the aptitudes, regulates the production, and contributes to ameliorate the "results and the economical conditions. Specialization renders the industry "accessible to all,—to moderate fortunes as well as heavy capital." The adoption of this system is now taking place in Philadelphia, with marked beneficial results. Another cause must always give France the pre-eminence The *arbiter elegantiarum* of the world in the fabrics of taste, she can impose by her imperial sway upon the followers of fashion throughout the world, the fabrics which she has created, leaving the other nations to supply imitations to the less fastidious masses.

England, who did not do justice to herself by her display of worsted fabrics at Philadelphia, has attained success in another direction. She aims to supply the world with worsted fabrics adapted for the consumption of the million. In extent of production and cheapness of fabrication she leads all other nations. It would be presumptuous to attempt, in the space allotted to this paper, even

a sketch of her vast worsted manufacture, while its characteristics, and the names of its principal fabrics, can be intimated, at least, under the head of our own worsted manufacture, which is in the main copied from that of England. A feature of some of the higher classes of her worsted fabrics displayed at the Exhibition should not be passed without notice. With the fashions at present prevailing, there is an extremely limited application of the arts of design in fabrics destined for personal wear. Even the printing of dress goods of wool and mixed materials, which offered a wide field for the application of art, has greatly declined, as the costumes of the present day obtain variety by the use of different hues of plain fabrics. An ample field for the application of art is found in stuffs for furniture, carpets, and hangings for rooms,—the furniture and curtain stuffs of worsted, or worsted and silk. The reps, damasks, and brocades showed the wonderful artistic progress effected by her schools of design and her teachers in practical art, such as Jones, Hulme, Morris, and Dresser. The displays of the Royal School of Art Needlework showed that the highest amateur taste of the kingdom is being brought into the service of the decorative arts, furnishing models and stimulus to the practical manufacturers. Through these influences, the designs for decorative fabrics have a style distinctly recognised as that of the "English school," in which mediæval motives are revived, plant-forms are conventionalised, while the natural treatment of foliage and flowers, and the artificial luxuriance of the *Renaissance* designs, are equally abjured. In the decoration of furniture stuffs of their own style the English are without rivals.

Before proceeding to a sketch of the worsted manufacture of the United States, which we shall give from purely original inquiries, it will be proper to refer to one of the most important steps in the progress of the worsted manufacture in this country, to which our own industry owes its importance. All-wool mousselines de laine were perfected in France in 1831. In 1833 a fabric first appeared in France which was a copy of the wool mousselines, with the difference that the warps were made of cotton. The English adopted this manufacture, at Bradford, in 1834–35. No event of the century has done more for female comfort and for the industry of wool than the introduction of the cotton warp. Cotton, instead of being the rival, became the most important auxiliary of wool, and has added vastly to its consumption. The *generic* name of cotton delaines, although now but little used, may be conveniently retained to express the whole class of these fabrics. They are practically the same as a woollen fabric, being so covered with wool that the presence of cotton can be observed only by the closest inspection. Their cheapness and durability make their introduction an invaluable boon to women of moderate means. Their fabrication constitutes the chief feature of the manufacture of the great cities of Bradford, in England, and Roubaix, in France.

THE PRINCIPAL COTTON WARPED, WORSTED FABRICS MADE IN BRADFORD AND THE UNITED STATES.

Names.	Weave.	Weft.	Warp.	Observations.
Delaines	Taffeta	Medium wood	Cotton	Printed.
Barèges	Gauze	„	„	A gauze weave.
Reps	Double-threaded taffeta	„	„	Printed.
Cashmeres*	Twilled	XX Merino wool	„	Made in imitation of cashmeres d'Ecosse, all wool.
Alpaca†	Taffeta	Long lustre wool	„	Weft originally made of alpaca.
Brilliantine	„	Fine mohair	„	Usually black, the warps dyed before weaving.
Lustres	„	An alpaca of lower grade	„	
Fancy alpaca	„	Figured fancy weave	„	
Brocade	„	A corded ground with a figure.	„	
Poplin	„	Long combing wool	„	A corded effect produced by the size of the warp.
Debaige	„	A fabric with weft of black and white wool mixed.	„	
Melange	„	The same, plain	„	
Italian cloths	„	„	„	

* Called "Coburgs" in England.
† Same fabrics originally called in England "Orleans."

The first attempt to fabricate delaines in the United States was made in a mill at Ballardvale, in the town of Andover and State of Massachusetts, about 1844, by John Marland, agent of the company. It is worthy of note as illustrating (what will hereafter be more conspicuous) how naturally and by direct descent the new industry arose and spread, that the mill at Ballardvale had been organised to make fine flannels, being first to fabricate flannels in the country. The transition was natural to delaines, which, as first made, had much of a flannel character. About 1844 this establishment imported worsted machinery from England, and made some delaines for printing and others for dyeing. They also introduced hand-combers, and made their own warps. The wools for the printed delaines were all combed by hand. The goods were first printed by blocks at North Andover, and afterwards on the machines of the Hamilton Manufacturing Company, at Lowell. The fabrication was very successful, although the goods were inferior to those now made. The principal difficulty encountered was that of introducing the fabrics into the American market, which was accomplished only by simulating foreign marks and disguising the boxes, to conceal the domestic source. This mill was subsequently leased to Mr. Jeremiah S. Young, who successfully continued the worsted manufacture.

The success at Ballardvale induced one of the oldest of the cotton-manufacturing establishments—the Amoskeag Company, at Manchester, New Hampshire—to try the new fabric. A mill owned by this company at Hookset, in New Hampshire, was devoted to an experimental trial, and Mr. Marland received an interest for conducting the manufacture, which was commenced with about 200 looms. The goods were printed at Greenwich, in Rhode Island. The fabrication was continued at Hookset for six or seven years, with a product of about 38,000 yards per week. The goods sold in the gray at about 14 cents per yard; wool sorts, which now cost 60 cents, costing but 36 cents, and cotton about 10 cents, per pound.

About 1845, certain of the stockholders of the Amoskeag Company organised the company now known as the Manchester Mills, situated in the town of that name, purchased a site and power from the Amoskeag Company, and built an extensive factory expressly for the purpose of making delaines. The cotton warps were originally made at Hookset. The first delaines were made at Manchester by carding, the wool-combers not being introduced until 1855, the Noble comber finally taking the place of the inferior combers of American invention first used. This company continued to improve its machinery and enlarge its production, which now reaches 250,000 pieces annually, of fifty yards each, the products having a reputation equal to that of any in the market.

The Hamilton Woollen Company, at Southbridge, Massachusetts, was originally established for the manufacture of cloths. About 1845 the leading stockholders of this company, who had been selling agents of the Amoskeag Company, seeing the success at Hookset, resolved upon converting the mill at Southbridge into a worsted factory. It met at first with little success, until its management was undertaken by Mr. Ballard, in 1846, who is still the treasurer of the company. The products of this mill, in printed delaines or reps, received deserved commendation at the Exhibition.

The line of descent in our worsted manufacture, which we have traced from the establishment at Ballardvale, was continued in the Pacific Mills, its first treasurer and the constructor of its works being Mr. Young, before referred to, a brother-in-law of Mr. Marland, who had gained his practical experience at Ballardvale. As this establishment is the largest in this country, and, as it is believed, in the world, where all the branches of the worsted fabrication are carried on within the walls of a single proprietorship, its exceptional importance will justify a somewhat extended notice of its history and operations.

The Pacific Mills are situated in Lawrence, Massachusetts, on the Merrimac River, twenty-six miles from Boston. The enterprise was started by the Essex Company, Mr. Abbott Lawrence being president and Mr. Young treasurer of the company. It was incorporated in 1853, under its present name, with a capital of $2,000,000, for the purpose of making ladies' dress goods from wool wholly, from cotton wholly, and from wool and cotton combined; and was provided with all the appliances of manufacture, including print and dye-works. The construction of the works having exceeded the amount of capital paid in, the establishment found itself, in the very first years of its existence,

on the brink of failure. This failure was arrested by the munificence of Mr. Abbott Lawrence, who, on his private responsibility, advanced several hundred thousand dollars to meet the emergencies of the mill, thus adding to his title for recognition as one of the great founders of the manufactures of New England. A hardly less important work of Mr. Lawrence was securing for the treasurership of the mills, vacated through the declining health of Mr. Young, the services of Mr. J. Wiley Edmands, who had been educated in his house. Mr. Edmands took the treasurership and the responsible management of the mills in June 1855. For the subsequent two or three years, the establishment, although actually making money, was only sustained by borrowing largely. In 1857 the leading commission houses of New England succumbed under the pressure of the well-known panic of that period. The Pacific Mills were compelled to ask an extension of credit for six months, to which every creditor assented. In 1858 the stockholders were called upon to furnish an additional capital of $500,000, of which all but $75,000 was secured. The stock representing thi amount, not secured, was sold at public auction, in 1859, at from $1320 to $1342 per share, the par value being $1000; although in 1857, two years previously, many shares had been sold at prices ranging from $75 to $200. During the first year of the war, 1861, the mills lost money, the product then being about 11,000,000 yards of dress goods, cotton and woollen. In 1870 the product reached 45,000,000 yards; and, for several years since that date, the annual sales, including the cloths purchased for printing, have reached about 65,000,000 yards. Of this, about sixty per cent. are stuff or worsted goods. Estimating our population at 45,000,000, and that one-third of this population (15,000,000) consists of women and girls, the Pacific Mills, which have all their consumption at home, supply not less than four yards of dress goods to each person of our population wearing these fabrics.

The following statistics of this establishment will give a better idea of the magnitude of its operations:—

Number of mills and buildings	12
Acres of flooring in buildings	41
Cotton spindles	135,000
Worsted spindles	25,000
Number of looms	4,500
Pounds cotton used per week	116,000
Pounds fleece wool used per week	65,000
Yards of cloth printed or dyed per week, more than	1,000,000
Printing-machines,—from two to sixteen colours	24
Tons of coal used per year	23,000
Number of steam-boilers in all (32,000 horse-power)	50
Number of steam-engines (1,200 horse-power)	37
Number of turbine-wheels (2,000 horse-power)	11
Cost of gas per year (5,000 burners)	$35,300
Cost of labour per month	$160,000
Average daily earnings, women and girls	98 cents.
Average daily earnings, men and boys	$1.40
Persons employed, women and girls, 3,534 Persons employed, men and boys. 1,766	5,300
Number of houses for work-people	275

To this it may be added, that the raw materials for dyeing and printing require an annual expenditure of $400,000; the consumption of potato starch is 500 tons a year, or the product of 125,000 bushels of potatoes; the wool consumed requires the fleeces of 10,000 sheep each week; while to all these are to be added the food and clothing of 5,300 operatives, and their dependants (at least twice as many more), and the items of transportation of raw material and manufactured products.

The company has never ceased its care for the welfare of its operatives, and their improvement morally and intellectually. It early founded a library, with reading-rooms, which contains nearly seven thousand volumes, and is open to the work-people and their families, and has actually an average of seven hundred daily readers. It has established a relief society for work-people temporarily ill, to which the operatives and the company contribute,

as well as a "Home," or hospital, provided with physicians and matrons, where those seriously ill can be better provided for than in the boarding-houses of the company, or even in their own homes. As the result of this recognition by the company of its moral responsibilities, there has been no disposition on the part of its operatives to organise strikes, all difficulties which have arisen having been amicably arranged. This moral work of the company was suitably recognised at the Paris Exposition of 1867, by the tribute to the company of one of the ten awards granted, among five hundred contestants, to the individuals or associations "who in a series of years had "accomplished the most to secure harmony between employers and their "work-people, and most successfully advanced their material, intellectual, "and moral welfare."

This mill has been selected as illustrative of our highest achievements in the department to which it belongs. We would by no means have it inferred that its products are superior to those of mills of less magnitude. The Manchester Mills, with an annual product of dress goods of 250,000 pieces of fifty yards each; the Hamilton Woollen Company, with a product of 800,000 pieces, and the Washington Mills, with a product of 2,000,000 pieces, manufacture worsted fabrics of no less excellence. It is due to the last establishment to say, that it was the first in this country to manufacture certain all-wool dress fabrics formerly obtained exclusively from France. Some of these fabrics which it was the first to introduce, such as the all-wool matelasses, are made not only by this establishment, but by Messrs. Martin Landenberger & Co. and Thomas Dolan & Co., of Philadelphia, and have high repute in our markets.

A very important class of dress fabrics was not undertaken in this country until 1872,—that of black alpacas, mohairs, and brilliantines. It was, not long since, believed that these goods could not be successfully made elsewhere than in Bradford, England. The Arlington Mills, of Lawrence, Massachusetts, were the first in this country to overcome the difficulties of this fabrication, and have since made a specialty of this branch of manufacture; these goods forming a large part of their annual production of five million yards. The black alpacas, mohairs, and brilliantines exhibited in great variety by this company, as well as by the Farr Alpaca Company, of Holyoke, were fabrics equal in all respects to the productions of the best manufacturers in the old-established seats of the worsted-industry in Europe.

Reference must be made to other worsted fabrics not included in the category of dress goods.

The manufacture of lastings, which are made from long-combing wools of English blood, has until recently been regarded as an exclusive English monopoly, and the English lastings at the Exhibition well sustained their traditional reputation. All attempts in this country failed until after 1867, when the Lowell Manufacturing Company first successfully achieved the fabrication of this article. They were followed by the Peacedale Manufacturing Company, of Rhode Island, and others; and at present the American shoe-manufacturers are largely supplied by lastings of domestic production.

Before the late war, English bunting, made like lastings of long-combing wools, formed the sole material for our national flags. The United States Bunting Company, of Lowell, first successfully achieved the manufacture of bunting. Its exhibits at Philadelphia showed not only excellent fabrics in bunting and moreens, but a marked improvement in the construction of the national flags.

In tapestries and upholstery stuffs of worsted or worsted mixed with cotton and silk, there was but one prominent American exhibition,—that made by Messrs. Kelty & Co., of New York; but this, in tastefulness of design and excellence of fabrication, was encouraging as to our future success in this attractive department.

CLASS 239.—*Carpets, Rugs, &c.—Brussels, Wilton, Tapestry Brussels, and Velvets, Axminster, Venetian, Ingrain, Felted Carpets, Druggets, Rugs, &c.*

Among the surroundings of our homes there are none which bring so palpably before our eyes the arts of design of remote centuries and distant peoples as carpets. Originating in Persia at a period almost on the verge of

history, and among a people of the ancient Aryan stock, among whose descendants in the centre, south, and east of that country are found the present chief seats of the textile industry of Persia, the carpet-manufacture was carried from thence to India, and to Arabia and Turkey. Carpets were introduced into Europe by the Crusades. Their manufacture in Europe was first undertaken in France, under the patronage of Henry IV.; and the manufacturing of carpets, under royal patronage, was founded at Beauvais, by Colbert, and still exists. Carpets in Europe, like china or porcelain, descended to the homes of the people from palaces, and the influence of original designs for royal establishments may still be seen in the gorgeous patterns of French carpets.

There were ample opportunities at the Exhibition for studying this, the most attractive department in the whole range of the textile industry, as it is the only one in which the arts of design have still unrestricted sway, and where the value of the fabric is controlled mainly by artistic considerations. Persia, India, Turkey, France, Germany, Austria, England, Scotland, and the United States, each exhibited its characteristic fabrics, and no important national product or variety of fabric in this department was without representation. We will briefly refer to the different national products, arranging them in the order of their origin, and availing ourselves of the artistic suggestions of Redgrave, Dresser, and Major R. Murdock Smith, under the light of whose illustrations they were observed.

The carpets of Persia first claim notice, specimens of which were supplied by Messrs. Sloane, of New York, our observation having been enlarged by a study of Persian carpets and rugs directly imported by them, making a museum of Persian art in this department not surpassed by the collection at Kensington.

The Persian carpets, or rather rugs, are made chiefly in Kurdistan, Khorassan, Feraghan, and Kerman (our principal authority for these statements being the notes on Persian art by Major R. Murdoch Smith, R.E.), each district producing a distinctive kind in texture and style. The finest are those of Kurdistan. In these carpets the pattern does not represent flowers, bouquets, or other objects, thrown up in relief from a uniform ground, like so many of the inappropriate designs of Europe, but looks more like a layer of flowers strewn on the ground, or a field of wild-flowers in spring. The borders are always well marked, and usually of brighter colours than the centre.

Besides the ordinary "Kali," or pile carpet, others called "Do-ru" are made at Kurdistan. These are smooth, without pile, and alike on both sides, and are used in travelling for spreading upon the ground.

The carpets of Feraghan resemble those of Kurdistan in style, although the texture is looser and the pattern simpler. They are, consequently, cheaper and in more general use. Fine Kurdistan carpets cost from three to four pounds per square yard. The Feraghan carpets cost from fifteen to eighteen shillings.

The Khorassan carpets are somewhat superior in texture to those of Feraghan, but the patterns are usually more realistic. Kerman carpets are next in value to those of Kurdistan, but the designs are usually still more realistic than those of Khorassan. Besides flowers, figures of men and animals are not uncommon.

According to Major Smith, the carpets of every description are made without even the simplest machinery, the loom being simply a frame on which the work is stretched. The woof consists of short threads woven into the warp by the fingers, without a shuttle. When a row of the woof is thus completed, a sort of comb is inserted into the warp and pressed or hammered against the loose rows of woof yarns until they are sufficiently tightened to the rest of the web. The pile is formed by merely clipping the ends of the woof until an even surface is obtained. The weaver sits with the reversed side of the web towards him; so that he depends solely upon his memory for the formation of the pattern.

The Persian carpets are usually somewhat long and narrow,—a form adopted because more easily woven, while it is adapted to the usual narrow dimensions of the Persian houses. The space for carpets on the floor of these Persian apartments is still further narrowed by the habit of laying strips of felt at the upper end and along the sides of the room, the narrow carpet

occupying the middle space. The spreading of Oriental rugs upon plain felt carpets, now somewhat in vogue, is an unconscious adoption of Persian fashions.

In an artistic point of view, the Persian carpets show an excellence so marked that the educated observer cannot have a moment's doubt as to their superiority over all other Oriental products of their class. They are distinguished by their subdued tones and the harmonies of their various colours. Various as they are, there are certain forms repeated in all designs, so that the national characteristics are clearly marked to those familiar with them.

Indian carpets (some beautiful specimens of which were shown in the Exhibition) are made in large single pieces adapted for covering floors of considerable space. Those exhibited, remarkably illustrated the characteristics of design pointed out by Mr. Redgrave. They had a great variety of colours, but so evenly distributed, and each so well balanced by its complementary and harmonising hue, that the general effect was rich and agreeable. The effect at a distance was a somewhat foxy tone, in consequence of the free admission of warm neutrals, as brown and brownish purple; white and yellow are but sparingly introduced to define the geometrical arrangement of the forms. The forms consisted largely of highly conventionalised flowers and plant motives, all geometrically constructed. These carpets were much more agreeable in tone than the real Turkey carpets at present so much in vogue.

The Turkish or Smyrna carpets, which were well illustrated, in the best specimens are generally designed with a flat (that is, without perspective) border of flowers of the natural size, and with a centre of larger plant-forms conventionalised, often to such an extent as to obscure the forms. The colours are negative shades of a medium or half tint, as regards light, and tending rather to dark, with scarcely any contrast, and therefore a little sombre in character. Three hues largely pervade the surface,—green, red, and blue. These are not pure, but negative, so that the general effect is cool, though rich, These remarks refer to the best types of the Smyrna carpets. There are others, especially such as are now so extensively imported and sold at auction in our principal cities, which are marked by violent contrasts,—a predominance of yellows and harsh violets. This deterioration may be accounted for by the fact that many carpets are now made in special manufactories, and that the modern carpets do not exhibit the traditional and inherited taste found in the ancient household fabrication.

It is certain that by far the best specimens of the pure Turkish style are found in what are called the Smyrna styles, made in large establishments in Germany and the Netherlands. Among them, the large carpets and smaller rugs made by the Royal Carpet Company of Deventer, Netherlands, were conspicuous for the taste of their designs, and chasteness as well as richness of colour. Nothing more fitting for the repose of a library could be desired than one of these carpets. As they are made by hand, the high price of labour in this country will not admit of their fabrication here. In looking at the best types of all the Oriental carpets, we cannot fail to be struck with the wisdom displayed by the Orientals in adopting negative tones for decorating the floors of their apartments. No people exhibit greater richness of upholstery and costume than those of Persia and India. In the subdued colours of their carpets, they have adopted the best means for enhancing and supporting the splendours of their furniture and the richness of their personal decorations.

The French carpets were represented by magnificent Axminsters, woven for large rooms, in a single piece. The most conspicuous was one representing a wonderful exuberance of tropical forms, in birds, flowers, and foliage; this fabric admitting the employment of an unlimited variety of hues, tones, and shades. The spectator, however, could not fail to be impressed with the thought that it was better fitted to be hung, as it was, as a drapery for a vast hall, than to be seen horizontally, and trodden under foot. This same impression was given by the Aubusson carpets, than which no fabric of wool can be intrinsically more perfect as works of art. They are, in fact, but tapestries for floors, and are fitted only for palaces or rooms decorated in the luxurious style of the *Renaissance*. Even here they would seem to detract from the

splendours of paintings and decorations adorning the walls. It seems difficult to eradicate the old ideas of florid decoration from French designers. It is a curious fact that the English now find in France the readiest sale for carpets designed under the influence of the modern English schools of art.

It would be useless to describe what is so well known,—the character of English and Scotch Jacquard Brussels, Wilton tapestry, and Axminster carpets exhibited, and it would be presumptuous to praise them. It is enough to say that they, as a matter of course, proved themselves to be, in texture and design, the worthiest models for our own manufacturers to imitate, and, if possible, to surpass. The observer could not fail to be amused by the singular mistake made by some of the largest English exhibitors, in displaying fabrics designed for adaptation to their own conceptions of American tastes. They seem not to have been aware that representations of lions, tigers, architectural panels, and huge bouquets are as offensive to the American as to the English educated eye. Recognising this mistake, an eminent English carpet-manufacturer remarked to one of our own at the Exhibition, "We seem to be "playing at cross-purposes; while we are manufacturing for the supposed "American taste, you manufacture for our own."

The carpet-manufacture of the United States has become so characteristic a feature of the American textile industry, that this report would be incomplete without a brief sketch of the steps by which it has reached its vast development. In the middle of the last century, a carpet was regarded as a curiosity in our most luxurious city of that period, Philadelphia; but, as early as 1791, a carpet-manufactory was established by Mr. William Sprague, which attracted so much attention as to induce Mr. Hamilton, in his famous report on manufactures, of that date, to recommend a duty on imported carpets, as an encouragement to home industry. The census of 1810 has been referred to as an authority for the statement that, in that year, 9,984 yards of carpet and coverlid, worth $7,500, were made in Philadelphia. The value indicates either the small proportion of carpets made or their very low value. No exact dates as to the further extension of this manufacture appear until 1825, at which time it seems that Mr. Alexander Wright, a native of Scotland, —who with others had previously started a small establishment for making carpets in Medway, Massachusetts,—visited a small carpet-factory in Philadelphia to learn the mysteries of the art. Meeting with no success, he went to Scotland, where he purchased looms, with which he returned to this country, accompanied by Glaude and William Wilson, who were employed by him to aid in operating his machinery, and who subsequently made considerable improvements in the Jacquard attachments to carpet-looms. The location of the works not being favourable, the property was sold to Mr. Frederick Cabot and Mr. Patrick T. Jackson, well known as among the founders of the cotton-manufacture of New England. In 1828, Messrs Cabot & Jackson sold the mill and machinery at Medway to the Lowell Manufacturing Company, which had been recently organised for the manufacture of carpets and cotton goods, the carpet machinery in the mean time being kept in operation until the mill at Lowell was completed. It should be observed that carpet-weaving at Medway, as well as that first undertaken at Lowell, was done on hand-looms.

It is within the personal recollection of the writer, that at about this time the manufacture of ingrain carpets was undertaken at Great Falls, in New Hampshire, by power, the apparatus for making the figure automatically being a large cylinder or drum, upon which pins or blocks were placed corresponding to the pattern to be woven, the cylinder operating like that of a music-box. This apparatus was also used at Little Falls, in New Jersey. This, as well as other automatic devices tried elsewhere, was finally abandoned, as operating less favourably than the hand-loom. In 1844 the hand-loom, both in Europe and this country, was universally used for making carpets.

The system was revolutionised by an American invention, which marks the period of its introduction as the most important epoch in the whole history of the carpet-manufacture. Mr. E. B. Bigelow, of Boston, Massachusetts, in 1842, conceived a series of devices for making the carpet-loom automatic, so that the costly labour of men might be dispensed with, and the whole process of weaving might be conducted by women or boys. After applying in vain to several parties engaged in the manufacture for the pecuniary means

necessary for the costly experiment which he proposed, he succeeded in gaining the attention of Mr. George W. Lyman, treasurer of the Lowell Manufacturing Company, through whose influence the construction of an establishment with the newly invented machinery was undertaken by the company, at a cost of many hundred thousand dollars. Mr. Bigelow was also seconded by Mr. Wright, the superintendent of the company, in the practical details of the adaptation of the invention. In 1845 the successful weaving of ingrain carpets by power had been demonstrated at Lowell, and its ultimate general use had become a fixed necessity of the manufacture.

Since this successful experiment at Lowell, the manufacture of ingrain carpets in this country has been marked by a constantly extending development. The important establishment at Thomsonville, Connecticut, now known as the Hartford Carpet Company, which used hand-looms concurrently with the Lowell Company, adopted Mr. Bigelow's invention. Each of these two is unsurpassed by any in the world making similar products, in the amount of production and excellence of fabrics; while many more recent and smaller establishments have their special excellences of fabric.

The patents for the inventions of weaving Jacquard Brussels and Wilton carpets, although offered to the Lowell Company, were not accepted, and it became necessary, finally, for Mr. Bigelow to utilise his own inventions. The result was the establishment of a factory at Clintonville, now Clinton, Massachusetts, in 1848, which was operated with success; and ultimately, of the organisation, in 1854, of the Bigelow Carpet Company, which became the possessor of the works and franchise of the concern just mentioned. This establishment, the growth of more than a quarter of a century, is now the largest in the world for the manufacture of Jacquard Brussels and Wilton carpets, in which the several processes of worsted spinning, dyeing, and weaving are united in one concern.

The American claim to the honour of this achievement of inventing the power-loom for weaving Jacquard Brussels and Wilton carpets is fixed by foreign recognition. The supplementary report of the jury at the World's Fair in London, 1851, where the inventor's carpets were exhibited, says,—

"The specimens of Brussels carpeting exhibited by Mr. Bigelow, woven by a power-loom invented and patented by him, are better and more perfectly woven than any hand-loom goods that have come under the notice of the jury. This, however, is but a small part of their merit, or rather that of Mr. Bigelow, who has completely triumphed over the numerous obstacles that presented themselves, and succeeded in substituting steam-power for manual labour in the manufacture of fine-frame Brussels carpets. Several patents have been taken out by different inventors in this country [Great Britain] for effecting the same object. But as yet none of them have been brought into successful or extensive operation; and the honour of this achievement, one of great practical difficulty as well as of great commercial value, must be awarded to a native of the United States."

Axminster carpets, adapted only for the most luxurious use, until recently made exclusively in France and England, are still woven in those countries on hand-looms. A patent for weaving these carpets by power, the invention of Alexander Smith and Halcyon Skinner, of New York, was granted in 1856. On account of the civil war, and the destruction by fire of the establishment where the invention was first applied, it did not come into considerable use before 1867, when the factory was rebuilt and the machinery set to work. The product of the establishment under the proprietorship of Alexander Smith & Sons is about 200,000 yards a year,—an amount believed to be equal to the entire annual production of the same kind of goods in France, and more than is made in Great Britain. One of these power-looms, attended by one competent woman, will produce in a day an amount equal to the product of ten English or French hand-looms, attended by as many men. The loom is not adapted for weaving the wide, single-piece carpets made in the foreign hand-looms; but this inconvenience is almost wholly obviated by the perfect selvage and matching of the figures of the narrow pieces, which may also be applied to floors of any dimensions.

Tapestry carpets, known as tapestry Brussels and tapestry velvets, form a very important branch of the carpet manufacture of England and the United States. This style of carpet, of quite recent invention, is particularly adapted

to the popular demand for brilliant effects at moderate prices, for there is no form of carpet in which so good an appearance can be secured at so low a cost. In all other carpets the yarns are dried. The principle of the fabrication of these carpets consists in *printing* the colours upon the warps in such a manner that when the warps are woven they form the desired figure. In this style of carpet the room for the application of colour and design is unlimited.

The method of printing the warps, which constitutes the essential feature of the tapestry carpets, was the invention of Mr. Whitock, of Edinburgh, Scotland, about 1838. The invention met little success until the right to apply it in England was secured by Mr. John Crossley, of Halifax, England, about 1842. With his characteristic energy and skill he made the fabrication a perfect success, and the establishment founded by him still makes the largest production of this fabric of any in the world.

In 1846, Mr. John Johnson, an Englishman, educated in Crossley's establishment, and who had himself put up the first machinery for this branch of fabrication at Halifax, came to this country, and established the manufacture of tapestry carpets at Newark, New Jersey, running above twenty-five hand-looms. He was facilitated in his enterprise here by the fact that Whitock had taken out no patents in this country. Mr. Johnson subsequently removed his establishment to Troy, New York, where the manufacture was carried on for two or three years under his direction, though not in his name. In the autumn of 1855 the machinery was purchased by a company, of which Mr. M. H. Simpson was the principal stockholder, and removed to Roxbury, Massachusetts, in 1856. The great inventive power of Mr. Simpson, seconded by the experience of Mr. Johnson, has secured for the Roxbury Carpet Company the prominence in this manufacture displayed by its beautiful fabrics at the Exhibition. This company has by no means the monopoly of this manufacture in this country. Its claims for excellence are contested by Messrs. Higgins & Co., of New York; Alexander Smith & Sons, of Yonkers; Stephen Sanford, of Amsterdam, New Jersey; Messrs. Dobson, of Philadelphia; and others.

The progress made in the manufacture since its first introduction is remarkable. The product of the first hand-looms was but five yards per loom per day. In 1856 the product of the Roxbury Carpet Company for each loom per day was sixteen yards. At present the average product of each of the one hundred and fourteen looms employed is forty-nine and a half yards per day. This is largely due to the invention of the power-loom of Mr. Bigelow, the principles of whose inventions are applied in weaving these fabrics.

Particular reference has hitherto been made only to the carpet-manufacture of New England and New York, which is characterised by its few vast establishments. The city of Philadelphia, alone, surpasses all other parts of the country combined in the extent and variety of the carpets which issue from its looms. A prominent characteristic of the Philadelphia manufacture is the diffusion of the industry in small establishments. Philadelphia, with its cheap homes, its abundant and cheap market, and the faculty which it seems to possess above all other cities of appropriating the talents of the artisans who resort to it, is the paradise of the skilled workman. There, as nowhere else in this country, the loom of the handicraft carpet-weaver still finds abundant occupation through the smaller manufacturers, who employ his skill, and furnish the raw material to be worked up by the weaver and his family in their own houses. The carpet-manufacture of Philadelphia is distinguished for its success in making sightly and useful carpets out of cheap materials, adapted for the most modest homes, and its carpet-makers are among the few American manufacturers who have been able to profitably export their products.

While small establishments form the rule in the carpet-manufacture of this city, there is one under an individual proprietorship of comparatively recent foundation,—that of Messrs. John and James Dobson,—which employs between two and three thousand workmen, principally in carpets. There are also notable exceptions to the general rule of manufacturing the cheaper products, Messrs. McCallum, Crease, and Sloane having exhibited ingrain carpets of the highest class (which, in design and fabrication, compared favourably with the best in the Exhibition), and the Messrs. Bromley, Venetian carpets illustrating the best merits of that class.

We have not attempted, in any other department, to exhibit the present amount of production; but the carpet-manufacture is so prominent a feature of our textile industry that we have taken pains to obtain, from original sources, the amount of production in 1875.

The Carpet Association of Philadelphia has furnished Mr. Lorin Blodgett, for his work on the industries of that city, the statistics of its carpet-manufacture in 1875. The report for 1875 claims the total value of the carpets manufactured in that city to be $19,000,000, and that the increase of machinery since 1862, in the form of mills, steam-power looms, &c., was more than one hundred per cent. Returns furnished to us by the following establishments outside of Philadelphia, viz., the Bigelow Carpet Company, the Hartford Carpet Company, E. S. Higgins & Co., the Lowell Manufacturing Company, and the Roxbury Carpet Company, show that the actual value of carpets made by these companies was $11,126,168. We feel authorised in estimating the product of other mills out of Philadelphia, not enumerated, at $2,000,000.

Résumé of American Product in 1875.

	$
In Philadelphia	19,000,000
Other mills enumerated	11,376,168
Not enumerated	2,000,000
Total value of American production of carpets in 1875	$32,376,168

The principal exhibitors of American carpets, by displaying them together in a series of alcoves, made their united exhibits in this department unusually imposing, and the proofs of our attainments in this manufacture were observed with no little surprise. It was manifest, from the absence of rival foreign exhibitors, that, in respect to the carpets of the cheaper and medium qualities, up to two- and three-ply ingrains, the competition is confined to our own manufacturers. Even rival English manufacturers generously admitted that, in the production of Jacquard Brussels, tapestries, Wiltons, and narrow Axminsters, we have nothing to learn from them either in design or fabrication.

Class 240.—*Hair, Alpaca, Goat's Hair, and other Fabrics, mixed or unmixed with Wool.*

Of the materials other than wool proper composing fabrics, but ranked with it because possessing the same general properties, the first in value is the product of the goat of Thibet, commonly called the Cashmere goat,—a distinct variety inhabiting the elevated regions north of the Himalayas. This variety, whose origin is obscure, has affinities with the Angora race. Its size is quite large. The horns are flattened, straight, and black, and slightly divergent at the extremities. The ears are large, flat, and pendent. The exterior fleece or hair, which is long, silky, and lustrous, is divided on the back, and falls down upon the flanks in wavy masses. Beneath the hair, there is developed in autumn a short and exceedingly fine down, called *pushm*, from which the Cashmere shawls are fabricated. The quantity of pushm obtained from a single animal is quite small, never exceeding one hundred and eight grammes, and usually much less, to the individual. The separation of the kemp or coarse hair from the pushm, which is indispensable for making the shawl-yarns, is a work of great labour. The raw or unprepared pushm, it is said, costs in India about seventy-five cents per pound; but the labour of separating the kemp, at the low rate of four cents a day, is so great as to bring the cost of the pure pushm up to seven or eight dollars per pound.

Well-arranged specimens of the pushm, as well as magnificent samples of the shawls fabricated from this material, were shown in the India collections. One in the Exhibition, imported by an English house, was valued at $1,137.

The prices of shawls, actually of Indian fabrication, descend as low as $20. The inferior shawls are made in Kerman, in Persia, as well as in India, from the material called "koork," proceeding from a particular kind of white goat, distinct from the Thibetian animal. Numerous flocks of these goats are kept at Kerman. They are cultivated in the same manner as the Merinos formerly were in Spain, being *transhumant*,—or feeding in the valleys in winter, and on the distant mountain-plateaus in summer. A large part of the Kerman koork is annually exported to Upper India, where it is manufactured into false India shawls. It is the koork, and not the pure cashmere pushm, as is commonly supposed, which forms the material of the richest of the Persian carpets, a magnificent specimen of which is in the collection of the Boston Art Museum; and an inferior one from Khorassan, now in Messrs. Sloane's warehouse in New York, although but six feet by four in size, is valued at $275.

The fabrication of cashmere shawls in Europe has been attempted only by the French. The peculiar Indian texture called "espouline" was perfectly achieved in Paris in 1834, four thousand workmen being employed, while some four hundred goats were imported from Thibet. But it was found that the raw material, expensive as it is, formed not more than one-tenth of the cost of a shawl; that the French workman could not compete with the Indian weaver, working at less than one-fifth of his wages; and that ladies of fashion would pay twice as much for a genuine India shawl as for a French article really superior in texture and design. The manufacture has, therefore, been abandoned. Since the monopoly of the East India Company has ceased, the French have reconciled themselves to the loss of this manufacture by making Paris the principal *entrepôt* in Europe of the India shawl trade. The inferior pushm or koork, from which the kemp is not separated, is at present largely used by the French in the fabrication of cashmere dress fabrics.

The next analogous material, in value and importance, occupying the place of wool, is mohair,—the product of the Angora goat. As this material could not be properly discussed under the head of wool, in the first part of this report,—while it is rapidly becoming an important object of American production,—it may not inappropriately receive consideration in this connection.

The Angora goat (descended, as proved by modern naturalists, from a distinct wild species of Thibet,—the Falconer's goat (*Caprus Falconeri*), it is supposed, was carried by the migration of pastoral tribes from Thibet, in the eleventh and thirteenth centuries, to the country in Asia Minor near Angora,—the ancient Ancyra,—where they principally abound, and from which the recent diffusion has taken place. Their existence was not made known to Europe until 1655, and the first full description of them was given by the celebrated botanist Tournefort, the master of Linnæus. But so little was popularly known of them, that some of the old dictionaries define mohair as the hair of a Turkish dog. The chief supply for commerce still comes from Asia Minor, the country being in the Turkish territory. The superbly mounted specimens of these animals in the Turkish department must be remembered by all visitors at the Exhibition.

The many attempts made to acclimate the Angora goat in various parts of Europe have met with signal failure, the generally prevailing moist climate being unlike that of their native habitat. The first importation into the United States, consisting of eight animals from Asia Minor, was made in 1849, by Dr. J. P. Davis. Other importations were made by Mr. Diehl. These and their descendants were distributed principally in the Southern States. Mr. Winthrop W. Chenery, of Belmont, Massachusetts, an eminent merchant and stock-raiser, imported about three hundred pure-blood animals, and introduced the first full-blooded animals of this race into California. Mr. A. Eutichides, a native of Greece, came to this country from Asia Minor in 1869, bringing a flock of Angora goats with him. A part of this flock was sent to California; the rest of the flock, numbering fifty-four, in 1875, is now in the possession of Mr. S. Fulmer, of Spring Mills, Appomattox County, Virginia, and has been kept perfectly pure. A flock of several thousand pure and grade animals of this race is upon an island in California, and several thousand are stated to be scattered through Oregon. The acclimation of the race, so difficult elsewhere, has been perfectly accomplished in the comparatively dry climate of this country, especially in the high regions of the South

and the interior. The only obstacle to success is the greediness of breeders, who are too apt to sell grade animals for breeding purposes. It is only by the constant use of absolutely pure bucks that merchantable mohair can be procured. For further information on this subject the reader is referred to a monograph on the *Angora Goat, its Origin, Culture, and Products*, by the writer, published in vol. xi. of the *Proceedings of the Boston Natural History Society*, and in vol. vi. of the *United States Reports of the Exposition at Paris of 1867*.

Mohair, the fleece of the Angora goat, is not a mere substitute for wool, but occupies its own place in the textile fabrics. It has the aspect, feel, and lustre of silk, without its suppleness. It differs materially from wool in the want of the felting quality; so that the stuffs made of it have the fibres distinctly separated, and are always brilliant. On account of the stiffness of the fibre, it is rarely woven alone; that is, when it is used for the filling, the warp is usually of cotton, silk, or wool, or the reverse. The distinguishing qualities of the fibre are lustre, elasticity, and wonderful durability. The qualities of lustre and durability, particularly, fit this material for its chief use,—the manufacture of Utrecht velvets, commonly called "furniture plush," the finest qualities of which are composed principally of mohair, the pile being formed of mohair warps, which are cut in the same manner as silk warps in velvet. Upon passing the finger lightly over the best Utrecht velvets, the rigidity and elasticity of the fibre will be distinctly perceived. The fibre springs back to its original uprightness when the pressure is removed. The best mohair plushes are almost indestructible, and are now in general use by all the principal railroads, as the most enduring of all coverings for railroad seats. The English have attained the greatest success in spinning mohair, and the French and German manufacturers use English yarns. In the manufacture of Utrecht velvets, the city of Amiens, in France, holds a marked precedence, and the plushes exhibited by her manufacturers, in Philadelphia, of all hues, plain and figured, well sustained her reputation. Another analogous application of mohair is for forming the pile of imitation seal-skins. Some of these fabrics, exhibited by manufacturers of Huddersfield, England, were of special beauty, the resemblance to real fur being quite striking. Admirable imitations in mohair of the Astrakhan lamb-skin furs were exhibited by the same manufacturers. Similar goods, made by one of our associate Judges, Dr. Weigert,—who, by his position, was precluded from an award,—received high commendation. Mohair forms an essential material in the best carriage and lap robes, with a long and lustrous pile. Some exhibited were made to resemble the skins of tigers, leopards, and other animals; and others were printed. Among the last, some made by a manufacturer in Sandford, Maine, were conspicuous for excellent texture and design. Another application of mohair is for the fabrication of braids for binding, which have the lustre of silk, but far greater durability. Excellent specimens of this fabrication were exhibited by T. M. Dale, of Newark, New Jersey. Still another important application of this material is in the fabrication of black dress goods, resembling alpacas, the mohair being woven with cotton warps. They are called mohair lustres, or brilliantines. Beautiful exhibits of this admirable fabric were made by the Arlington Mills and the Farr Alpaca Company. Mohair is also used in France in the manufacture of laces, which are substituted for the silk laces of Valenciennes and Chantilly. These, however, do not come within the consideration of this group.

The soft fibre of the vicuña of South America, composing fabrics which are peculiarly agreeable in feel, was exhibited in very pleasing shawls made by English and California manufacturers. But the most interesting of the new fabrics were the cloths made of camel's down, which have recently come into extensive use in Russia.

The Roumianstoff Cloth Manufactory of General Siloverstoff, situated in the Volga Province of Russia, exhibited beautiful plaids, blankets, and other tissues, adapted for the most luxurious consumption, manufactured from picked camel's hair and goat's down. These products find a ready sale in Paris. More interesting still was a stout and leather-like, though soft, cloth, without nap, made from a mixture of Merino, Russian, and Kirghese wool, with camel's down, called "half-merino." This is dyed a pale yellow tint, and finds an extensive sale among the Asiatic tribes under the name of *jeltiak*.

These tribes, from time immemorial, have dressed in yellow cloth made exclusively of undyed camel's hair. The appearance of a dyed cloth in which the camel's hair was mixed with wool, acquiring greater strength, yet having the same colour, has caused the Asiatics to substitute the jeltiak for the original camel's hair fabric. This cloth has now great repute among the Caucasian Armenians, and the Persians living on the coasts of the Caspian Sea. The success of this manufacture is in a measure due to the invention of a particular apparatus by means of which the soft and downy parts are separated from the fleeces of coarse Siberian and Kirghese sheep and goats, the down of the Siberian goat producing stuffs remarkable for their softness and lightness.

The celebrated Montagnac coatings, first made in France about twenty years ago by processes patented by the inventor whose name they bear, had beautiful illustrations at the Exhibition, from Sedan. They are sometimes called cloth-velvets. The pile of the surface is usually furnished by fibres of cashmere wool, incorporated in the yarns of the fabric, and they are straight and perpendicular to the surface, the cloth having the aspect of a silk-velvet, but with a softness peculiar to the cashmere fibre. The pile is developed on the surface by *battage*, or beating the moistened cloth with elastic rods.

Formerly, only the long hair of the cashmere goat and camel were used, besides wool, for making pile fabrics. In 1850, Mr. Benjamin Crosland, of Huddersfield, England, invented or re-discovered a process by which the short hairs of the cow and calf could be used in the manufacture of imitation seal-skins. The mean feature of his process consisted in boiling the fabrics for a long time in water, which develops the lustre of the fibre. These fabrics were for a long time imported into the United States under the pretence that they contained no wool, being thus subjected to a less duty. A rigorous microscopic examination by the National Academy of Sciences, made quite recently, under the direction of the Secretary of the Treasury, seems to have established the fact that the short hairs of the cow and calf are spun with at least enough wool to carry the fibre,—a successful spinning seeming otherwise impracticable. The cow-hair seal-skins, which are an important speciality in England, were illustrated by beautiful specimens at the Exhibition.

Another animal product which is not strictly a textile fibre, because it cannot be spun like those above referred to, must be considered in this connection,—that is, horse-hair, the material of the fabric ordinarily known as "haircloth." This material, as a covering for furniture, a century ago was held in high consideration. The wife of Benjamin Franklin, describing the furniture of her mansion in Philadelphia, says it was covered with black hair-cloth, "as handsome as *padisoy*" (Padua silk). Modern fashion has driven this material from fashionable drawing-rooms, but its durability still causes it to be retained in unambitious apartments. There were two conspicuous exhibits of this material. Ranking first in elegance was an exhibit made by Edward Webb & Son, Worcester, England. These haircloths were woven in stripes of rich blues, scarlets, and crimsons, with whites, and in simple but rich colours, brocaded and figured. They possessed all the elegance which could be given to this material, and for certain purposes, as for summer apartments and houses in tropical regions, possess adaptations found in no other upholstery materials.

The Pawtucket Haircloth Company, of Rhode Island, made an exhibit of this fabric, the peculiarity of which was that it is the result of the first successful weaving of haircloth by power, the hand-loom being, so far as know, used by all other manufacturers of this fabric at home or abroad. The success of the company referred to is due to their achievement of the work of picking up, and applying automatically, each individual hair which is to compose the texture of a hair filling, interlaced by a warp of cotton thread. This is accomplished by a little machine which could be packed in a box two inches square. This machine, which is detachable for repairs, is attached to a loom, both the machine and loom being operated by power, and it forms the pivot upon which the whole manufacture turns. It is essential that the machine should pick up but one hair at a time. To accomplish this, the picker in the machine has a groove or slit invisible to the naked eye, so that the whole of this manufacture turns upon a point which can only be seen with a microscope. The loom is so adjusted that the movement of the web is arrested until the

picker lifts up its hair. The end of the hair is seized by a rod, the end of which operates like a thumb and finger, and is carried transversely between the warps. This little apparatus is attached to four hundred distinct looms in the establishment of the company. One girl tends ten looms, and this one girl, by means of this machinery, does the work requiring twenty operatives on hand-looms. By means of these appliances, this single establishment, employing only 150 work-people, produces 600,000 yards of haircloth per annum, each loom weaving five yards per day. It consumes annually 450,000 pounds of horsehair, equivalent to the tails of 600,000 horses. The large exhibit showed the unquestionable superiority of the machine-made goods to the ordinary hand-loom fabrics.

All the classes assigned to the Judges of this group, in the department of wool, have now been considered, except that of wool machinery. While all the varieties of wool fabrics were well illustrated, the wool machinery exhibited but very few of the modern appliances by which the fabrics are made. The fullest description of the machines exhibited would give but a faint idea of the improved machines now in use. To describe even those exhibited would require space and means not at our disposal, and would be unsuited to the popular object of these reports.

Silk and Silk Fabrics.

By John L. Hayes.

Silk with its fabrics, by the value of the raw material, corresponding to an equal weight of silver, its tenacity equal to that of iron, and its lustre surpassed only by that of the precious metals and stones; by the splendour of its fabrics, their relations to the decorative arts, their influence upon painting, heraldry, and the ceremonies of the church, their place as a means of exchange in early commerce, and the correspondence of their production in Western Europe with the decline of Oriental power,—would seem to claim a more extended notice than we have given to the homelier fibre and fabrics which have thus far occupied our attention. But the popular interest attaching to silk and its fabrics has made knowledge of this subject so general that we could hope to add little to the common stock of information as to the sources of this fibre or the history of its Oriental and European fabrication. Besides, we do not forget that the principal source of the popular knowledge of this subject in this country is the exhaustive report prepared by Mr. Cowdin, the Chairman of this group, in his former official position as an American Commissioner at the Paris Exposition of 1867; and that it would be vain to expect to glean from a field which had been so thoroughly reaped and harvested.

The writer will confine himself, in this portion of his report, to a brief sketch of the more general impressions made by the foreign exhibits of fabrics of silk,—omitting notices of the raw material, and not attempting any analysis or minute comparison of foreign fabrics,—and to a notice, more extended, of American products.

Before proceeding with these sketches, it is but an act of duty for the writer to refer, as he can without indelicacy, to the character of the work performed by the subdivision of the Judges of Group IX. intrusted with the examination of silk. They consisted of Mr. Gustav Gebhard, a practical manufacturer of Elberfeld, Germany, one of the most celebrated and extensive fabricants in Europe, whose facility for work in this department was aided by his rare command of all the Continental languages; Mr. Louis Chatel, an eminent manufacturer of Lyons, who, confined to his chamber by an unfortunate accident, still insisted upon having samples of all the fabrics under examination submitted to him in his chamber; Mr. Hayami Kenzo, an accomplished Japanese gentleman, the Government Director of silk-reeling establishments in his own country; Mr. August Behmer, an Egyptian gentleman, familiar with the production of raw silk; Mr. John G. Neeser, a Swiss gentleman; and Messrs. Cowdin and Le Boutillier, Americans,—the latter three of very large experience in the silk trade. All the exhibits were carefully inspected in the cases by the Judges of the subdivision, and submitted to subsequent examination and tests through samples. The sewing-silks and twists exhibited were submitted to rigorous tests by machines and otherwise, to determine their smoothness and tenacity; careful notes being taken of these experiments.

Brief as the awards are in this subdivision, their value is greatly enhanced by the high character of the Judges and their conscientious and rigorous examination. To American exhibitors in this department, especially, will the high awards they have received from foreign manufacturers, from whom even mention is praise, be of peculiar value. The writer, instructed, as he could not fail to be, by daily intercourse with his accomplished associates, and guided in his observations by their direction, has less diffidence in offering the notes which follow.

France.

France, as occupying the first position among the silk-manufacturing nations, having had a production in 1874 of $116,000,000, and an export of $95,000,000,—a production three times as great as Germany, which next follows her,—commands the first notice. The principal French display of silks, being in a somewhat secluded court, was made more pleasing from the exclusion of other objects, and the brilliancy of the fabrics was enhanced by the extreme simplicity of the cases inclosing them. No section of the Exhibition was more attractive than this court, displaying as it did the models of perfection in the most luxurious department of the textile industry, and the most brilliant and artistic products which the weaver's art can create. In this court were gathered the substantial proofs of that aspiration for ideal excellence in the material, fabrication, and artistic form of her products, which has given to France the crown of industrial glory. With all the pleasure conveyed to the eye and senses by graceful designs and infinitely varied colours, by gorgeous decoration and unexpected combinations of material or colour, perhaps the chief satisfaction derived from the inspection of the products of this court resulted from the consciousness that they were the best results hitherto attainable by human effort in one great department of industry. Another vivid impression made by this court was that the industry it displayed was the product of an æsthetic culture, general and special, without example in the world, and of influences such as have existed in no other nation. The industry was planted by the royal foresight of King Henry of Navarre, and sustained by the political economy of Colbert. It grew up in the genial atmosphere of the most splendid courts of Europe. The chemistry of Berthollet and Dumas furnished dyes for its fabrics; the traditions of the Renaissance and the pencil of Watteau gave it designs; and Chevreuil imparted to it the secrets of harmonising and contrasting colours. While, in later periods, the protective influences of the Government (whether empire or republic) have never been wanting, the pre-eminence of the silk manufacture of France has been sustained by the working population who have inherited the traditions and secrets of manipulation from generations of artizans, and by art schools for workmen, which Lyons was the first city in the world to inaugurate.

The visitors at the Exhibition, whose imagination had been excited by the learned researches of Michel upon the precious stuffs of the Middle Ages, or the splendidly-coloured plates of the characteristic silken tissues of every period recently published in Paris, might have experienced some disappointment at the comparatively small display of the figured brocades, damasks, and velvets so conspicuous in the personal costumes of the earlier periods. Mainly, as is asserted, through the influence of the Franco-Prussian war, which plunged France into mourning, the figured and brocaded stuffs were replaced by plain fabrics in personal costumes, although now beginning to reappear. It may not be generally known that it is in the perfect fabrication of the plain stuffs, especially the plain black silks, that the highest art of the manufacturer consists, as no inequality of thread or unevenness of tissue or dye can be concealed by the figure. Of the plain tissues of this description in this section recognised by the expert Judges as of incomparable excellence, it is useless to attempt a description. To be appreciated, they must be seen or worn.

There was no lack of fabrics whose beauty was due to design and colour. Conspicuous among them were printed foulards, upon which the arts of design and of impression would seem to have been exhausted. The miraculous power of the Jacquard loom to produce the most complicated designs

was most tastefully and appropriately shown in a woven representation in silk, upon a background of tissue, about two feet long and as many broad, of the mulberry in leaves and fruit, with the silk-worm and moth in every state of development; the colours exquisitely shaded, the mulberry branch being intertwined with a ribbon bearing the significant motto, *vestit, ornat, ditat.*

Although decoration is sparsely used in stuffs for dresses, it still finds an infinite field for application in stuffs for upholstery, and especially in fabrics for church vestments. Antiquarian learning seems to have exhausted itself in seeking examples and authorities in the past for forms and colours of ecclesiastical vestments. Silk, gold, silver, and jewels glitter on the copes, the chasubles, the mitres, the stoles, and altar-cloths, of the church more prodigally, and combined with higher skill, than they could have done in the most splendid period of mediæval history. It is said that in some of these tissues the workman can weave not more than an inch in a day, and the prices sometimes attain the enormous sum of three hundred dollars per yard. The most brilliant display of these fabrics, as well as those for upholstery purposes, was made by Messrs. Tasiman & Chatel; the latter being a Judge, the exhibit was precluded from an official award. Their magnificence equalled all that the imagination could conceive. An interesting feature of some of these fabrics was a reproduction of Oriental types, illustrating the views maintained by the learned M. Michel, that the figures on heraldic coats of arms were derived from silk stuffs of the East, of which the representation of animals —such as lions, leopards, eagles, griffins, &c.—formed the ordinary ornament. On one of the fabrics exhibited by Mr. Chatel, with a background of gold and red, was interwoven, so as to cover the surface, repeated figures of elephants, horses, falcons, cocks, dogs, deer, and mounted horsemen; all designed conventionally, or in heraldic style.

To illustrate the extent and variety of the silk products and producers of France, as well as to pay a deserved tribute to the typical silk-manufacturers of the world, we subjoin a list of the principal French exhibitors, with the products:—

Black silks	C. J. Bonnet's Sons & Co., Lyons.
Black silks	Jaubert, Audras, & Co., Lyons.
Black silks	Tapissier Son & Debry, Lyons.
Black silks	Gourd, Croisat Son, & Dabost, Lyons.
Black silks	Antoine Guinet & Co., Lyons.
Black and coloured velvets	Gautier, Bellon, & Co., Lyons.
Black velvets and coloured silks	J. P. Million & Servier, Lyons.
Black velvets	Font, Chambeyron, & Benoit, Lyons.
Black silk velvets	C. J. Servant & Co., Lyons.
Black dyed silks	Gillet & Son, Lyons.
Dress silks and novelties	Poncet, Senior & Junior, Lyons.
Coloured silk goods	Faye & Thévenin, Lyons.
Silk goods	Sevène, Barral, & Co., Lyons.
Damask silks and novelties	Bresson-Agnès & Co., Lyons.
Coloured failles and gros-grains	Bardon & Ritton, Lyons.
Striped and fancy silks	Mauvernay & Co., Lyons.
Siciliennes	Audibert, Monin, & Co., Lyons.
Poplins	J. Drogue & A. Monnord, Lyons.
Foulards	A. L. Trapadoux & Co., Lyons.
Foulards	Jandin & Duval, Lyons.
Foulards	Gondard, Cirlot, & Martel, Lyons.
Hatters' plushes	Huber & Co., Paris.
Black and coloured satins	Brosset-Heckel & Co., Lyons.
Hatters' plushes	J. B. Martin, Tarare.
Crapes	Montessuy & Chomer, Lyons.
Umbrella silks	Alex. Giraud & Co., Lyons.
Velvet ribbons	F. Brioude, St. Etienne.
Velvet ribbons	Giron Brothers, St. Etienne.
Sewing-silks	Benoit, Tabard, & Co., Lyons.
Silk gauzes and bolting-cloth	L. Dornon, Lyons.
Bolting-cloth	L. R. Gascou, Montauban.
Raw and sewing-silk.	Joseph Puydebart, Lyons.

Germany.

Germany, although ranking second in the production of manufactured silk, —having had a production of the value of $38,000,000 in 1874—was represented by few exhibitors, awards having been made but to four exhibitors; viz., to Escales & Hatry, of Saargemünd, for silk plushes for hatters' use, of remarkable perfection in colour and finish; to Gressard & Co., of Hilden, for foulards of high excellence; to Carl Mez & Sons, of Frieburg, Baden, for sewing-silks of great beauty in colour and finish; Massing Brothers & Co., Püttlingen, for hatters' plushes of high excellence.

But the paucity of exhibitors from Germany was atoned for by the beauty of exhibits made by Mr. Gustav Gebhard, of Elberfeld, who, on account of his position as Judge, was precluded from an award. In the absence of the notes promised by Mr. Gebhard, we are compelled to trust only to our own memoranda and impressions. The products of the establishment represented are understood to be furnished by the labour of some four thousand persons, not employed (as with us) in a single establishment, but working hand-looms in their own houses. The goods, exhibited in two very large cases, and most tastefully arranged, consisted of figured velvets, satins, and brocades, many of them executed in silver and gold. A striking feature of the exhibit was the designation by cards of the markets for which the several fabrics were specially destined. India, Siam, Batavia, Constantinople, had each their special fabrics, in which the characteristic features of the native productions of different Oriental countries were reproduced, doubtless with cheaper materials, but with attractive effects.

India.

The reference to copies of Oriental fabrics leads us naturally to the original fabrics of silk which were exhibited from the East. The India Museum's most attractive and instructive exhibit contained beautiful specimens of India silks. Conspicuous among them was a brocade long scarf, or *Kincob*, from Benares, in which, from silver leaves placed on a dark or deep-red ground, spring gold flowers with black centres. Another brocade, of wonderful beauty and exquisite texture, is composed of a gold ground, varied or shaded by delicate shades of silk, in low tones of blue and red. The figures in these brocades are all conventionalised. Still another attractive fabric was a fine silk gauze, embroidered with gold in flattened or hammered scales.

More instructive to the student of textiles than the few large and brilliant samples of fabrics was the collection, made under the direction of the East India Museum, of the splendid volumes, albums, and framed samples of all the textile fabrics of India, in which the wonderful variety and perfection of the native silk fabrics of India are admirably displayed. The expense of a series of these samples (about two thousand dollars) forbids their possession by individuals; but none of our industrial or art museums should fail to have these admirable models of industrial art-work.

Netherlands Colonies.

Among the silk fabrics shown at the Exhibition, there was nothing surpassing the scarf-like brocades from Sumatra and Java, exhibited in the collection of the Netherlands colonies. They belong to the native princes, and were lent for the purpose of exhibition in Philadelphia. They were all of native production. A model of a rude loom was exhibited, upon which they are said to have been woven. But it seems inconceivable that such fabrics could have been produced by such rude mechanism. The ends of the scarfs are fringed with flat tassels of silver, rudely made and unpolished. The fabric is of silk of a dull red tone, shot with gold thread. The terminal borders are well marked and broad. The designs are arabesques of a geometrical construction,—no figures of flowers or animals being introduced,—but of a most subtle and ingenious character. Although the texture is nearly covered with gold, it is scarcely apparent; and the general tone of the fabric is low and subdued. This subdued effect is produced by the neutral tone of the silk, and the manner in which the design is made to spread all over the texture.

China and Japan.

Japan and China, although leading all other nations in the supply of raw material, and in silken embroideries unequalled, were inferior in the artistic character of their woven goods to India and Java. The plain coloured satins of China were of excellent manufacture; and a fine exhibit consisted of coloured and figured silks, which were declared by the Judges to be marked improvements over former productions of that country. Among the exhibits from Japan, the most conspicuous for excellence were the silk crapes, white, dyed, and printed; the dyed cherries and scarlets being notable for the perfection and brilliancy of their hues, while others were most skilfully shaded. Productions of silk from cocoons of worms feeding on the walnut, and others from worms feeding on the oak, were interesting. The most curious of the Japanese fabrics were brocades of great apparent richness, on account of the gold woven in the tissue; gold flowers and leaves being intermingled with scarlet flowers upon an indigo-blue ground. The threads of gold forming the warp, upon close examination, were found to consist of exceedingly narrow or thread-like slips of paper, gilded, but only on one side; the gilded side being invariably brought to the surface in the tissue. It was observed by experts that this effect could only be produced in hand-looms.

Turkey, Egypt, Tunis.

The less remote Oriental nations—Turkey, Tunis, and Egypt—showed that they had not lost the arts of silk fabrication which they once enjoyed in supreme perfection. The damasks and brocades, woven in silk alone, or mixed with gold and silver, though Oriental and characteristic in design, in many cases exhibited excellent taste and workmanship.

Russia.

Russia, combining Oriental sentiment and traditions with the art and technical skill of Western Europe, made exhibits of silk fabrics which worthily attracted universal admiration. We refer particularly to the damasks and brocades of silk, gold, and silver, the latter literally "cloths of gold and silver," made in Moscow and St. Petersburg, and the sacerdotal vestments in gold and silver tissues made in the same cities. These tissues, vying with the best productions of Lyons in execution, have a characteristic interest and beauty, derived from the traditional splendours of the Greek Church. Some of the rich fabrics were especially noticeable from the pure Byzantine character of the design, employing religious symbols, which Ruskin has pointed out, in his *Stones of Venice*, as characteristic of the earliest Christian or Byzantine decoration. The notable exhibitors of these magnificent stuffs were A. & W. Sapojinkoff, Moscow; John Sytof, St. Petersburg; Mosjookhin & Sons, Moscow; and F. A. Jevargeif, St. Petersburg.

The ordinary silk fabrics exhibited by Russia were of high excellence. Among those deserving special mention are Sergius Zoobkof, of Khomootovo, Moscow, for rich coloured failles; Alexis Fomitchef, Moscow, for rich figured failles and silk cashmeres; Kondrashef Brothers, Grebenevo, Moscow, for plain black and coloured failles and upholstery damasks; Emilianoff & Rochefort, and Zolotaref & Ribakoff, Moscow, for silk and wool dress goods; Shelaief Brothers, Moscow, for black and coloured satins.

Mr. A. Néboltine, a Russian statistician, says, "We commenced in the last "century to manufacture silk in Russia; but it is only during the present "century, and above all since 1830, under the influence of a protective tariff, "that this fabrication has become developed, or acquired any considerable "importance." He shows that in 1872 there were 460 silk-factories, 15,800 workmen, and an annual production of 10,300,000 roubles, including the production of trans-Caucasia, which is more of a domestic than manufacturing character; and that the importation of foreign silks in 1871 was of a value of 6,293,935 roubles, or a little more than half that of the national fabrication.

Switzerland.

Returning to the more prosaic regions of the European silk-manufacture, we find that Switzerland best represents the fabrication adapted to the ordinary

commercial demands of modern times. Zurich, the chief centre of the fabrication, occupies the same position in the silk manufacture that Bradford does in the worsted and Verviers in woollen industry. She manufactures for export and for the million. Economy of production is the first object. Although provided with very cheap labour, Switzerland has led other nations in the application of labour-saving machinery, and she has chiefly furnished the models for the best machinery used in this country, both in the manipulation and dyeing of silk. She excels in the combination of cheaper materials, such as cotton with silk; the silk being thrown upon the surface, and the cotton forming the back, as in cotton-backed satins and marcelines. Although producing the higher classes of dress silks, black and coloured, in great perfection, as evinced in the beautiful exhibit of Baumann, Aelter, & Co., of Zurich, the characteristic of the Swiss manufacture is the adaptation, for popular consumption, of fabrics which are made attractive by taste in design, excellence in execution, and reasonableness of price. An interesting evidence of the confidence of the Swiss manufacturers in holding their own ground against foreign rivals is the circumstance that the Swiss Commissioner, alone among foreign representatives, caused a series of albums, most beautifully arranged, containing samples of all the silk products exhibited by his country, to be presented to the principal industrial museums and associations of this country. One of these albums the writer has now before him. In this album there are no rich brocades, damasks, or velvets, and nothing conspicuous in an artistic point of view. The fine gros-grains and failles, black and coloured, exhibit great regularity and perfection of execution. The figured silks are marked for the simplicity and delicacy of their designs; the fine stripes, so difficult of execution, being perfect. The few brocades are tasteful, but not showy. The marcelines and the satins, with either cotton-tram or chain, are very effective, especially in the materials for cravats. We must not omit a product in which silk, ordinarily ministering only to luxury, contributes to the first of necessities. It forms the material for bolting-cloth used in the manufacture of wheat flour. In the manufacture of this fabric the Swiss have attained the utmost perfection. The leading exhibitors, with their products, were:

Black and coloured failles and taffetas.	Adlischweil Silk Goods Factory Adlischweil, near Zurich.
Black and coloured gros-grains and failles.	Beaumann, Aelter, & Co., Zurich.
Black and coloured failles	S. Rutschi & Co., Zurich.
Marcelines	Ryffel & Co., Staefa and Zurich.
Coloured and figured dress-silks	Emil Schaerer & Co., Zurich.
Coloured failles and changeables	J. Schwarzenbach-Landis, Thalweil, near Zurich.
Plain, striped, and check dress-silks	Joh. Stapfer's Sons, Horgen, Zurich.
Cotton-back satins	Stunzi & Sons, Horgen, Zurich.
Dress-silks	Baumann and Streuli, Horgen, Zurich.
Low-priced cravat materials	Jansen, Bodek, & Hertz, Reisbach.
Black and coloured gros-grains and brocades.	William Schroeder & Co., Zurich.
Silk bolting-cloths	Meyer Brothers, Zurich.
Silk bolting-cloths	Heidegger, Wegmann, & Co., Seefeld, Zurich.
Silk bolting-cloths	Ruff Huber, Zurich.
Silk bolting-cloths	Egli & Sennhauser, Zurich.
Silk bolting-cloths	Homberger Brothers, Wetzikon.

Austria.

Austria, which more properly should have been considered in connection with Germany, exhibited black silks well adapted from their low price to a large consumption, cotton-back velvets, and silk velvets, black, coloured, and white, of excellent manufacture. The prominent exhibitors were:

Black silks	S. Trebitsch & Son, Vienna.
Cotton-back velvets	Carl Hetzer & Sons, Vienna.
Fancy silks	C. G. Hornbostel & Co., Vienna.
All-silk velvets	F. Reichert's Sons, Vienna.
Hatters' ribbons	J. Swartz & Son, Vienna.

Great Britain.

Great Britain failed to make any adequate representation of her manufacture, although it counts by millions of pounds sterling in value. There were only four well-marked exhibits. Pim Brothers & Co. did high credit to Ireland, by a splendid display of their black and coloured hand-woven plain silk poplins, which are celebrated throughout the world, and by furniture damasks of fine effect. Norris & Co. made an excellent display of upholstery silks, which were specially noticeable for admirably executed designs, in great variety, all conceived in the spirit of the modern English school. Admirably executed figured and emblematical ribbons were exhibited by Thomas Stevens, of Coventry, as well as an excellent silk loom of quite original construction. There were two excellent exhibits of sewing-silks.

Italy.

Italy, who, in the fourteenth and fifteenth centuries, supplied all Europe with the richest fabrics of silk, equally disappointed the visitor at the Exhibition by her display of fabrics in this department; only a single exhibit of figured velvets from Milan being noticeable. A series of rich antique stuffs in the Castellani collection, however, gave the visitor some conception of the ancient splendours of the silk fabrication of Italy.

Spain.

The political condition of Spain prevented her from making the display of which she would have been otherwise capable. Spain is still a treasure-house of the splendid stuffs of the past, most of the richest ornaments of the Kensington Museum having been obtained in that country. We are assured that many of the traditionary arts of silk-weaving have been preserved, particularly in the religious houses. Black silks of good manufacture, and black cashmere silks in fine grades, well made in every respect, were exhibited; also curtains, furniture damasks, and brocades in good colours; effective stuffs for cravats and fichus, and hand-made figured silks in old Moorish and Oriental styles. The principal exhibitors and products were:

Black silks	Antonio Pascual & Co., Reus, Tarragona.
Black cashmere silks	Farriols & Son, Barcelona.
Curtain and furniture damasks	Benito Malrehy, Barcelona.
Silk cravats and fichus	Eduardo Reig & Co., Barcelona.
Valencia silks in old Moorish styles	Fernando Ibanez Palenciano, Valencia.

Portugal.

Portugal surprised us by the excellence of several exhibits of gold and silver damasks for church purposes, and of rich brocades and brocatelles for furniture and curtains, as well as well-made dress silks; all evincing an unexpected progress in that country towards industrial independence. The leading exhibits were as follows:

Gold and silver damasks	David José da Silva & Son, Oporto.
Gold and silver cloths	Viuva Ferreira Campos & Co., Oporto.
Upholstery stuffs	National Silk-Weaving and Spinning Co., Lisbon.
Gold and silver galloons and gimp	Custodio Lopez da Silva Guimaraes, Penafiel.
Black and coloured failles and brocatelles.	Ramires & Ramires, Lisbon.

In observing, as we do in this slight sketch, the high attainments made in silk fabrication by countries regarded as barbaric, as well as those possessing all the modern inventions, we perceive that there are no conditions in any country, where civilization has dawned, preventing the appropriation of this industry. The raw material, unlike wool and cotton, from its high intrinsic value, compared with its weight, being almost as transportable as the precious metals, is almost equally available to every country. Where traditionary skill,

which still nourishes the manufacture in the declining countries of the East, is wanting, or favourable circumstances, like the exodus of silk workmen into England from the revocation of the Edict of Nantes, do not exist, the encouragement of governments and the enterprise of the people must give the impetus to a manufacture which every self-dependent nation aspires to plant upon its soil. What these influences have accomplished we shall now attempt to trace in the history of the silk fabrication in our own country.

Silk-culture and Fabrication in the United States.

The exhibits of American silks at Philadelphia were, without question, the most triumphant trophies of achievements in the textile industry within the last two decades displayed by any nation or department of textile fabrication. The brief period within which our silk-manufacture has reached its high position tempts us to describe the steps of its progress. But a detailed history would be unsuited to the general plan of this report, while any attempt at original historical research in this department is rendered unnecessary by the full "particulars in relation to silk and the silk-manufactures, chronologically arranged, prepared by Mr. Franklin Allen, Secretary of the Silk Association of America," published in the *United States Industrial Directory of* 1876; and by the exceedingly well written and carefully executed *History of the Silk-Industry of America, prepared for the Centennial Exposition by L. P. Brockett, M.D.*, and published under the auspices of the Silk Association of America. These works will be freely drawn upon without further acknowledgment. The writer will add that he has verified the observations of Mr. Allen and Dr. Brockett, as well as his own impressions and notes at the Exhibition, by a recent personal visit to most of the representative silk-manufacturing establishments in this country.

The Silk-Culture.—We will first notice the growth and extension of the silk-culture in this country. The production of the raw material was attempted in the earliest periods of our colonial history, in the Southern colonies, where the conditions of climate were most favourable for the growth of the mulberry and the raising of silk-worms; but the more profitable culture of tobacco and rice, and subsequently of cotton, together with the incapacity of the only working population of the South, the negroes, to perform the delicate operation of reeling, caused the silk-culture, in that section, finally to wholly disappear. It was more successful in Connecticut, where the conditions of climate were less favourable, but where the necessities of the people, and their habits of thrift, had developed an active household industry.

Through the influence of Dr. Stiles, afterwards President of Yale College, a State bounty was given, in 1763, for the culture of the mulberry and the production of raw silk. In 1766, half an ounce of mulberry-seed was sent to every parish in the State. The domestic culture of silk was very general in the State during and subsequent to the Revolution. It became a fixed industry, however, only in the town of Mansfield, where it had been introduced by Dr. Aspinwall, in 1766. This town became noted for the production of silk grown and reeled in the households. "Mulberry orchards," of the hardy native white mulberry, were distributed throughout the township, and rows of this tree shaded the highways and fringed the cultivated fields. The production of silk in a single family sometimes amounted to one hundred and thirty pounds in a season, and most of the labour was performed by women and children. The silk, very imperfectly reeled, was spun on a hand-wheel into a roughly-made sewing-silk (dyed in the household), which was usually sold in barter to the country stores. The floss, waste, and pierced cocoons, being mixed with wool, cotton, or flax, were made into coarse stuffs for every-day wear. The domestic production of this town from 1820 to 1831 was of an annual value of not less than $50,000. In this domestic manufacture, as we shall hereafter see, were the germs of the present silk-industry of America.

From 1780 to 1820 the domestic culture and fabrication of silk was also pursued to some extent in New Jersey, Pennsylvania, and parts of New York, Delaware, Maryland, and Virginia, but without any results bearing upon the extension of the manufacture, as in Connecticut.

About the period of 1825, with the growing sentiment which then prevailed for the extension of American industry, the public attention was attracted by means of congressional reports, messages of State governors, and publications

by enthusiasts in the press, to the field for American industry which lay open in the silk-culture and fabrication. Among the individuals most prominent as writers and practical experimentists, though with no results profitable to themselves, were Mr. Duponceau, of Philadelphia, and Judge Cobb, of Dedham, Massachusetts. Their appeals found a response in the public mind, dictated by the natural desire to appropriate the most attractive and luxurious of the textile arts, together with a new product for our soil. But the means by which the much desired industry should be planted were not yet made clear. At an unhappy moment, Dr. Felix Pascalis made known to the public the remarkably rapid growth and supposed excellent qualities of the *Morus multicaulis*, first planted in the United States in 1826. In place of the old method of planting the well known and hardy, but slow-growing mulberry-trees, it was proposed to secure leaves fit for feeding from trees of a single season's growth, which seemed possible through the extraordinary luxuriance of growth of the multicaulis variety. The public were taught that every farm should be a nursery for the young trees, that every house should have its cocooneries, and that silk would become as cheap as cotton. At first gradually, and then more and more rapidly, the excitement in regard to the multicaulis grew, until it reached a speculation, whose extent and folly, and the ruin it brought in its collapse, in 1839, are too well remembered to need any further notice. With the subsidence of the multicaulis fever, there came a general decline of interest in the silk-culture, except in Mansfield, which had so thoroughly tested the value of the white mulberry as to partake but little of the prevalent excitement. There, however, the mania for speculation, which seems to have been an epidemic of the times, was transferred to the white mulberry. The fever had its course and its reaction. Silk-culture sank into disfavour in the town to which it had given prosperity for nearly seventy years. Finally, in 1844, a blight of a general character, to which even the hardy white mulberry yielded, gave the finishing blow, and silk-culture in America ceased to exist.

But the silk-culture, humble as it was and brief in duration, was the means of developing a knowledge of the fibre, of its uses, and manipulations; it drew attention to the possibilities of the fabrication, and created a passion for working it. The silk-culture was the humble larva from which was developed the winged and perfect insect, brilliant with gold and colour, to which the perfected silk-manufacture may not unaptly be compared.

Fabrication of Machine and Sewing Silk.—Proceeding to a history of the organised manufacture of silk in this country, we find that two of the most important branches of the manufacture, that of sewing silk and spun silk, were direct offshoots from the domestic silk culture of Connecticut. Attempts were made at Mansfield in 1810, 1814, and 1821, by Rodney Hanks, to manufacture sewing silk by power, but without success. His grandsons are now successful manufacturers. In 1829 a company, consisting of seven individuals, most of whom subsequently became identified with numerous enterprises in the silk manufacture, was incorporated under the name of the Mansfield Silk Company. Their first successful machinery was made by Mr. Lilly, the promoter of the enterprise, in accordance with the descriptions and rude drawings of Edmund Golding, a young English "throwster," who came to this country at the age of seventeen, expecting to find employment in his art. But the machinery proving inadequate for the manufacture of American silk, as it was then reeled, raw silk for the first time was imported from England and used in the manufacture of sewing silk, which proved superior to the hand-made skeins. From that first successful attempt, the manufacture of sewing silk, by power, has been uninterruptedly continued, though with successive improvements in machinery, as well as in the quality of the goods made. This company, having unwisely entered into the culture of silk, was finally dissolved. Several members of the disbanded company started the manufacture of sewing silks in other places, and contributed to the spread of the new industry. An ingenious mechanic of Mansfield, named Rixford, made improvements in the machinery for winding, doubling, and reeling, which were adopted in a mill started at Florence, near Northampton, out of which the now celebrated Nonotuck Company's establishment sprung. So that in the humble domestic silk-culture of Mansfield may be clearly seen the source of the present manufacture of sewing silks and machine twists in this country, amounting in 1875 to over six million dollars in value.

This is, at present, the characteristic department of New England in the silk manufacture, and the few details which we are able to offer in relation to this branch of silk fabrication can be most appropriately given in this connection. So numerous have the establishments become (twenty-five in Connecticut and Massachusetts, besides those in other States), and necessarily so active is the rivalry between them, that it would be invidious to specialise the several contributions which they have made to the high advancement of this great branch of the silk manufacture.

The first object sought by the early sewing-silk manufacturers was to rival and replace in our markets the Italian sewing-silks in universal use; and the sewings, at first, were put in packages with Italianised labels, simulating Italian sewings. Although dealers had the usual distrust in American productions, our early manufacturers were aided by the long voyages between this country and Europe, which often caused temporary deficiencies in the supply of Italian sewing-silks. By filling up these gaps, our manufacturers got their first hold upon the American markets. At first, only coloured silks were attempted; competition with the superior black sewings of Italy being considered hopeless. Advancing in the fabrication, and attaining a permanent black dye, through its introduction in 1838 by Messrs. Valentine & Leigh, who had been practical dyers in England,—one of whom, Mr. Leigh, still survives,—they undertook a fabric in greater demand,—black sewing-silks in skeins, for tailors' use. The sewing by the hand, and the simple needle then in sole use, demanded a far less perfect thread than that now required for machine-sewing. Illustrations of the solidarity of the industries are perpetually recurring. The American invention of the sewing machine was the inauguration of the sewing-silk manufacture of America, in the forms and proportions which it now holds. The sewing machine required that silk for its use should be put upon spools, and be of a special manufacture. The proprietors of an establishment in Massachusetts, now famous, knowing the difficulties attending the use of silk threads, as then made, upon the newly-invented sewing-machine, devised the plan of twisting the silk in a direction opposite to that of common or skein sewing-silk. Winding a pound of three-cord silk, thus twisted, upon spools containing one half ounce each, they submitted it, in 1852, to Mr. Singer, who was then experimenting upon his newly-invented sewing-machine, with which he met difficulties that he could not overcome. We cannot so well describe this important step in the manufacture of sewing silks as in the language of Mr. Lilly, a proprietor in the establishment referred to. The silk was handed to "Mr. Singer with the request that he would try it. He put "a spool upon his machine, threaded up, and commenced sewing. After "sewing sufficiently to enable him to judge of its merit, he stopped, and, after "examining the work it had done, exclaimed, 'Can you make any more like "this?' (addressing the agent, who stood watching the result with great "interest:) 'I shall want all you can make,'—a prophecy literally fulfilled. "The new fabric assumed the name of 'machine twist'; and from that time "to the present the amount of silk consumed upon sewing-machines is "marvellous. A new enterprise was born, which created an industry giving "labour to many thousands."

Although, in this first experiment of machine-twist, the invention was complete, the manufacturers still found great trouble in its production; for the machine required a thread which, to be moved automatically, must be absolutely perfect, like the machine itself. It was by gradual improvements in machinery, and manipulations generally too minute to warrant description, that they succeeded in the result they have now so completely attained,—that of placing upon spools a definite weight of silk thread, of continuous length, entirely free from slugs, knots, and uneven places, and perfectly adapted to the machine which is to apply it. We may, however, mention as American inventions, which have contributed to the advancement of this manufacture, new mechanical patented devices for spooling the thread and weighing it; and especially a machine in general use for stretching the thread after it has been twisted, which has the effect of lengthening the thread about fifteen per cent., and of making it even throughout. As the manufacture advanced, the standard of excellence, both on the part of the producer and consumer, grew higher. In the earlier stages of manufacture, the black silks were heavily weighted by chemical means; greatly diminishing the tensile strength of the

thread,—a system then invariably pursued by the makers of foreign sewing-silks. Certain American manufacturers then introduced goods of strictly pure dye; and, to insure the consumer against fraud, also introduced measuring and strength-testing machines, by means of which the buyer might inform himself of the actual value he had in each pound of twist. In time, the makers placed upon the goods their own names and brands or trade marks, like the well-known designations, "Nonotuck," "Corticelli," "Lion," "Eureka," &c., which are absolute guarantees, to the consumer and dealer, of the quantity and quality of the goods sold. The direct tests to which the American sewing and machine silks are subjected, in this country, by the ready-made clothing manufacture, unequalled by any other in the world in the extent and systematical character of its operations, has contributed greatly to the perfection of this branch of the silk manufacture. That the United States may now challenge the world in the fabrication of sewing-silks was fully demonstrated at the Exhibition, as here before said. All the sewing-silks exhibited were subjected to the most severe tests by the expert Judges. A result of these careful tests was the conclusion of the Judges, that certain American sewing-silks exhibited surpassed, in all the qualities which make up the sum of excellence, any displayed by foreign nations.

The statement of the aggregate production of sewing-silks and machine-twists in this country fails to show the large scale upon which this manufacture is conducted, and the activity of enterprise in this department. A better conception may be formed from the facts, that in a single establishment not less than six hundred operatives are constantly employed, and its consumption of raw reeled silk in the present year is one hundred and three thousand pounds of raw silk, of a value of about twelve dollars per pound. As an illustration of the rapidity with which this manufacture has been expanded, it may be stated that a firm of manufacturers who commenced the sale of sewing-silks in 1856, with a capital of twenty-five dollars, in 1876 consumed no less than three thousand pounds of raw material in their own manufacture, gave employment to one thousand hands, and sold a value of about eight hundred thousand dollars.

Before leaving this branch of the silk manufacture, we must not omit to notice the machinery in actual operation at the Exhibition, illustrating the methods in use in this country for fabricating sewing-silk. A description furnished by an expert correspondent of the New York *Times* is better than any we can offer. The machinery in operation was exhibited by the Nonotuck Company, of Florence, Massachusetts, and the Danforth Manufacturing Company, Paterson, New Jersey. The writer from whom we quote says,—

"To begin with, the skeins of raw silk, just as they come from China or Italy, are strung upon winders, for the purpose of being wound on to bobbins. This is a very simple process, and done on very simple machinery; the only mechanical aid of any consequence being a reciprocating cam, which gives a lateral motion, and distributes the strand of silk equally over the bobbin. These bobbins are then transferred to the 'doubling' machine, on which any number of threads, from three up to ten, are wound together. But this machine involves one or two very pretty movements. As in the case of the winder, the equal distribution of the combined thread on the bobbin is regulated by a reciprocating cam; but a very neat attachment also stops any one bobbin the moment one of the threads, making the combined thread, snaps. Immediately under the bobbin on which the threads are jointly wound there is an arm rising from a balance-frame. Should one of the threads snap, the guide, through which it runs, and which is only supported by its tension, falls back against the balance frame. Its weight is sufficient to displace the frame and bring forward the arm; and the arm, having an elevation, raises the bobbin and unships it, at once stopping its revolution. By this ingenious arrangement, the main thread is kept of one continuous size without any trouble, because it cannot run on without the companionship of all the minor and component threads. On being taken from the doubling-machines, the bobbins are placed on the 'spinner,' which gives the various threads a sufficient spin to make a strand in the process of unwinding. The bobbins then go to the 'twisting' machine, on which the threads from three of them are firmly spun and twisted together to make what is called machine-twist silk, but from only two bobbins to make sewing-silk. Both kinds of silk are twisted twice,

but with this great difference: machine-twist is first twisted to the right, and then to the left; while sewing-silk is first twisted to the left, and then to the right. The silk is then rewound into skeins, and, after being washed in strong soap-suds, is dried and stretched. The length of these skeins is regulated with great nicety by an ingenious adjustment. An eccentric drives a ratchet-wheel with a dog on it, and the adjustment causes the dog to strike the shipper and stop the winding machine the moment the desired length of silk has been wound into the skein. The silk is now ready for the dyer, and, after being dyed, is again wound in bobbins preparatory to 'spooling.' The spooling-machine has a feed-shaft, with a right and left hand thread on it, and a half-nut on either side. This arrangement gives an easy and regular direct and reverse lateral motion to the guide, the spool remaining stationary; the length of silk wound on to the spool is regulated by a binder and a strap attached to a weight, both being governed by a treadle. The operator knows exactly how many times the guide should travel right and left to fill the spool. By pressing the treadle the weight below the shaft is raised, and releases the strap from the shaft; while at the same moment, and equally governed by the treadle, the binder (which is a small wheel) presses the belt against the shaft, causing it to revolve. The moment the spool is full, the operator ceases to press the treadle, the binder releases the belt, and the strap, attached to the weight below, falls on the shaft and stops it instantly. The same arrangement enables the operative to stop the revolution of the shaft in case of accident to the spool or thread, as the machine cannot run unless the foot is pressing on the treadle; and, the moment the pressure ceases, the machine comes to an instantaneous stop. One of these spooling-machines will wind one hundred and ten dozen of spools a day; and some conception of the extent of the Nonotuck Company's business may be gained from the fact that they have no less than sixty of these spooling-machines in constant operation in their factory, where they employ over six hundred hands. Only one thing has to be done to render the spools ready for the silk; it is to stamp their two ends with the brand and the name of the company. This is done by one of the prettiest and most perfect little pieces of machinery in the hall, and the stamping of the colours into the wood obviates the falling off of printed labels, as is sometimes the case with cotton spools from insufficient gumming in the labelling-machine. The spools are fed from a trough, through a hollow post, into the stamping machine; an arm pushing them one by one, as they come out at the base of the post, into a groove, where they are caught and held in position by a small weight, the spool at the same time pushing back a spring. Two spools are in the grooves at one time, the one receiving its first and the other its second stamping simultaneously. At either end of the spools are two dies, one inked with red and the other with blue ink. These dies press upon the spools simultaneously, impressing the name of the company in one colour, and, on the second impression, the brand in the other colour. The outer spool is then released by the momentary rising of the weight, and the spring against which it was pressing kicks it out into a basket. The groove-bed revolves, bringing the inner spool to the outside and a new spool into the place of the inner one; the operation being repeated *ad infinitum*. As the dies spring back from the spools, they take a quarter turn upward, which brings them under the inking rollers; the rollers being inked and moving in a similar manner to those in a job-printing press. There are four composition rollers to each ink reservoir and pair of dies. The whole stamping-machine is divided into two parts, each the counterpart of the other, and turns out the stamped spools at the rate of one hundred and twenty a minute. One machine will stamp seventy thousand to eighty thousand spools a day, sufficient to fill ten ordinary flour-barrels. When wound on the spools, the silk is ready for the completion of orders, or to go into stock in the warehouse."

The Fabrication of Spun Silk.—It was in the silk-culture that the largest and most celebrated of our manufactories of silk goods, that of the Cheney Brothers, had its birth. As this establishment is wholly without rivals in its special department, and one of the most characteristic in the whole range of the American textile industry, it commands a special mention which would be invidious in other branches of the silk fabrication.

The sons, eight in number, of a farmer in South Manchester, after the custom of the town had cultivated mulberry-trees and raised silk-worms in their boy-

hood. Some remained at home, while others were scattered, but only to return. For four or five years previously to 1838, four of the brothers had been raising silk-worms and producing silk, like their neighbours. In that year they started a small silk-mill at South Manchester, for the purpose of making sewing-silk. Their increasing interest in the silk-culture, however, led them to suspend the operations of the mill for a time, when three of the brothers removed temporarily to Burlington, New Jersey, where they established nurseries and cocooneries, and published a magazine known as the *Silk-Grower's Manual*. Their energy having, however, been mainly devoted to planting nurseries of the multicaulis, and their plans having been frustrated by the explosion of that bubble, in 1839 they returned to their forsaken mill at South Manchester, and resumed the work of making sewing-silk from imported raw silk. Subsequently, they were rejoined by others of the family, who had established mulberry plantations in Florida and Ohio. We do not propose to follow the steps by which this establishment reached its present vast expansion. Success came slowly, and after many discouragements, and with it an enlargement of operations. In 1854 a mill was built in Hartford. Buildings were added at South Manchester, new machinery and methods invented and imported, while new branches of manufacture were added to that of sewing-silk. The main feature of the manufacture in time came to be the working into every conceivable fabric that form of silk known here as spun silk, and on the Continent of Europe as *chappe*. This is silk spun from pierced cocoons, floss, and waste, and whatever cannot be reeled. The fabrics from this material, though wanting in the high lustre of those made from reeled silk, are remarkable for their wearing qualities, their beauty actually increasing with wear. The extensive use of this material for dress goods and ribbons is quite recent; but these fabrics, as now made by Messrs. Cheney Brothers, are recognised as cheaper and better than any goods of their grade in the market. The leading articles produced in this establishment are black and coloured gros-grain silks, which have obtained a wide-spread reputation for their cheapness and good wearing qualities, as compared with imported goods of corresponding grades and weight. Ribbons of all colours and widths, which are among the most popular brands in the market, and a great variety of silks for the millinery and trimming trade,—for parasols, and for hat and fur linings. The expert Judges at the Exhibition recognised in their award to Messrs. Cheney Brothers the "high degree of excellence of the piece goods and ribbons exhibited, and the perfect manipulations of the spun silk in every form."

But the proud distinction of this establishment is not so much the unequalled character of the fabrics in its peculiar line, its army of fifteen hundred workmen, or its production exceeding two millions in annual value, as the manner in which it has solved the highest and most difficult of problems,—the securing commercial success, with the harmony of interest between the employer and the operative. It would seem that neither taste nor social science could devise happier adaptations for the wants of a manufacturing population than are found in the village of South Manchester. In a highly-kept park of seven or eight hundred acres, without a single inclosure, are scattered the beautifully appointed factories and warehouses, the handsome residences of the proprietors, the churches and public halls, the convenient boarding-houses, and the two hundred dwellings of the workmen, each isolated, with a pleasant garden-plot, and provided with water, gas, and perfect sewerage. The large farm of the proprietors, near the village, furnishes a supply of milk and vegetables at moderate prices; and an extensive bakery contributes to the public convenience. The intellectual wants of the workmen are provided for by a first-class school, a library and reading-room, and a commodious hall for lectures and public entertainments. The dream of an ideal community seems here to be as completely realised as is possible with the inexorable conditions of labour and capital. It is gratifying to see that the enlarged views of the proprietors have been productive of commercial success. An obvious result of their system has been to secure and retain the best class of workmen. There has never been a strike in this establishment; a strike being held, in the words of one of the proprietors to the writer, "as disgraceful to the employer as to the operative."

Woven Goods of Reeled Silk.—To observe the American fabrication of silk in its most luxurious forms and in the utmost variety, we must leave New England, and seek a district in New Jersey and New York, comprising the

city of Paterson, its chief centre, and outlying establishments in Brooklyn, Hoboken, and New York City. In this district, and particularly in Paterson, lying about twenty miles by rail from the great metropolis, may be seen, in successful activity, nearly every form of silk fabrication pursued in Europe. It is a law of the development of industries that they spring from some obscure germ, as the tree grows from its seed. Like the sewing-silk and the spun-silk manufacture, the magnificent industry of Paterson grew out of the silk-culture of Connecticut. It was founded by Christopher Colt, Jr., whose father was a president of a Connecticut silk-manufacturing company, which existed from 1835 to 1839, and an enthusiast in silk-culture. An uncle of Christopher Colt, Jr., was the inventor of the celebrated revolving pistol, and had built a large factory in Paterson, then a town of about seven thousand inhabitants, for the manufacture of his pistols. He offered the fourth story of his mill, with power to drive machinery, to his nephew Christopher, for the establishment of a silk-mill. It was supplied with machinery and started; but at the end of three months it was closed, and the stock, machinery, and fixtures offered for sale. Happily at this time, namely, in 1839, John Ryle, of Macclesfield, England, who had learned the arts of the silk-manufacture in his native town, was attracted to this country by the glowing statements sent abroad by the promoters of the *Morus multicaulis* excitement, then at its height. He visited Northampton and Connecticut, witnessed the collapse of the multicaulis bubble and the extinction of the silk-manufacturing establishments which had embarked in the speculation, but only to be more vividly impressed as to the field which lay open in this country for silk manufacture. Imparting his enthusiasm to a Mr. Murray, a capitalist, whom he fortunately met at Northampton, the latter was induced to buy out Colt's machinery and place Mr. Ryle in charge of the first successful silk-mill in Paterson.

In 1843, Mr. Ryle having become a partner with Mr. Murray, the firm employed fifty hands, and consumed eight thousand pounds of raw silk per annum, in the production of tram, sewing-silk, and twist. In 1846, Mr. Ryle was assisted by his brothers in England to buy out Mr. Murray's interest, and, being sole owner of the establishment, set some looms at work, and produced several pieces of dress silks. But this fabrication was not continued. In 1857–58 he employed from four to five hundred operatives, and consumed two thousand pounds of raw silk per week. For twelve years he was without any competitor in Paterson. His first successful rivals were Messrs. Hamil & Booth, who commenced business in Paterson as throwsters, in 1854, with twenty operatives, but who now give employment to nine hundred. Even as late as 1862, the manufacture of silk at Paterson was mainly restricted to the making of machine-twists, sewing-silks, and tram-silks, for the use of manufacturers of silk trimming located in other cities. Efforts were made, in the years 1846, 1849, and 1864, to introduce the weaving of broad silks; but the experiments were only successful in demonstrating the skill of manufacturers. In 1862–63 material improvements were made by the machinists of Paterson in the construction of the silk-spinning machinery required for the fabrication of fine trams and organzines, the yarns necessary for weaving broad silks; and a greater uniformity was attained in assorting the various sizes of yarns required for weaving, which was effected by the introduction of the processes known as *deniering* and *draining*.

In the mean time, the command of the domestic market, assured by the tariff of 1861, encouraged manufacturers in Baltimore, and in Williamsburg, New York, to embark in the weaving of ribbons, scarfs, neckties, &c. The establishment at Williamsburg was transferred, in 1867, to Paterson; and, under the name of William Strange & Co., now employs eight hundred operatives, turning out an annual product of ribbons of the value of over a million of dollars. There are now eight ribbon-manufacturers in Paterson, and the production of this single city is over one hundred thousand pieces of ribbon per month.

The permanent establishment of broad-silk weaving in Paterson dates from the period of 1866. It was first successfully effected there by the Phœnix Manufacturing Company, and was made successful through the production of the yarns before referred to. This establishment now employs nine hundred operatives, and is distinguished for its perfection in Jacquard weaving. At first, eighty per cent. of the broad silks made was used for ladies' ties. In 1872 other firms entered into broad-silk weaving. The

increase in the number of looms was followed by variety in production, until, as at present, there is scarcely a product of European looms in millinery, and even the highest class of dress-silks, which does not find its rival in the Paterson factories.

The command of skilled labour, the admirable water-power, the vicinage to the metropolis, and, above all, the well-known advantages of centralising the manufacturers in a special department of a textile industry, have led several important silk manufacturers, first located in Boston, Williamsburg, Schoharie, New York, and New York City, to transfer their establishments to Paterson.

A prominent advantage of centralising manufacturing establishments is the opportunity given for specialising certain departments of industry. This is shown at Paterson in the great success attained in an essential branch of the silk manufacture,—that of dyeing. The concentration of silk manufactures at this place has produced the largest and most perfectly appointed dyeing establishment in the country, in which a large part of the fabrics produced in Paterson are dyed on commission. The proprietors of this establishment, Messrs. Weidmann & Greppo, educated in Europe, and related to eminent dyers in Lyons and Switzerland, have introduced the best processes and machinery known abroad. One group of machines just introduced for stringing and shaking the yarns, for the purpose of straightening and stretching them after being dyed, does with three or four men what formerly required the severe labour of sixty stout men. Their relations with Lyons and Zurich keep them promptly informed as to the latest improvements and fashions. Their exhibit of dyed silks was one of the most attractive, and that of black weighted silks was one of the most instructive, at the Exhibition. Four years ago the dyers of Paterson held that it was impossible to perfectly dye pure black silks in their establishments on account of supposed defects in the water of the place. A dye is now given in black dress-silks fully equal to the celebrated black dyes of St. Chaumond, near Lyons. The American dyers of black silks refrain from the reprehensible practice of European manufacturers of heavily weighting their black silks by means of chemicals. It is said that the average of French black silks are weighted as high as one hundred per cent. The weighting may be carried, without detection by the eye, as high as three hundred per cent.; but very brief wear reveals the deception. It is by no means claimed that there is higher morality on the part of American manufacturers. But the sins of the producer for a domestic market fly back to him so promptly and certainly, in the form of reclamations, that interest compels honest fabrication.

"Dyeing," said the immortal Colbert, "is the *soul* of tissues, without which the body could scarcely exist." This is especially true of silks: the attainment of the arts of perfect dyeing is the overcoming of the last obstacle to a successful manufacture. Fashion, constant only in change, is perpetually varying her demand for new colours, hues, and tones. She is inexorable even as to the most delicate shades. A ribbon or dress-silk may become absolutely unsaleable, at any moment, by a change of fashion. Hence the advantages which Paterson enjoys in the perfection of her dyeing establishments, and of a taste instructed by a vicinage to the great metropolis. The taste of the present times, it may be observed, demands the almost exclusive use of aniline dyes in coloured silks. They are more vivid and enduring on silk than on any other raw material, and, though still comparatively fugitive, are no more so than the fashions. Black, brown, and drab are almost the only colours for which anilines are not used.

To recur to the more general features of the silk-industry of Paterson. Its importance is shown by the facts obtained from the report of its Board of Trade of 1876: number of operatives, 8,000; amount of silk used each week, 9,000 pounds; number of ribbon manufacturers, 8; number of broad-silk factories, 6; and about 150 hand-looms, worked by men in their own homes. Most of the spinners use their own silks. The average wages of men weavers per week, $15; women and boys, $7. The value of the total production yearly is about $6,000,000.

We have dwelt at length upon the silk industry of this city, because it is representative of its class. Important manufactories of woven silks, broad goods, and ribbons are found in West Hoboken and Union, in New Jersey, and in New York City: such as those of Herman Simon, in Union; Givernaud

Brothers, in West Hoboken; John N. Stearns & Co., and J. Silbermann & Co., in New York City, &c. All the silk-manufacturing establishments of New York and New Jersey, including those of Paterson, may be said to be manufacturing appendages of the city of New York. The manufacturers nearly all have their warehouses and partners in the city, or visit it daily, and the goods are dispatched each day to the city sale-rooms. Some were originally importers of silk goods; others still continue importing in connection with their manufacturing operations. Thus a knowledge of the wants of the trade, of the changes of fashions, of the coming styles, is secured, which would be unattainable except through the influences of a great metropolis.

A few words may be given to some of the improvements made in the silk fabrication, which may be observed in the centre of manufacture now under review. Machinery for throwing has recently been introduced at Paterson, by which a spindle which formerly made three thousand five hundred revolutions per minute now makes seven thousand, doing its work as well as that more slowly revolving. It is claimed that these machines, some of which contain nearly seven hundred spindles, are capable of producing double the amount of work per spindle than can be done with the largest European frames; and that they can be managed by two attendants, one on each side. Winding, which ten years ago cost by piece-work one dollar per pound, costs now forty-five cents; the girls earning more than at old prices before the improvements. A new Swiss machine, just introduced, reduces the cost of warping from ten cents to five cents. The old machines, moved by hand, contained eighty bobbins; the new one, moved automatically, contains three hundred. A new loom for weaving hat-ribbons makes two hundred and fifty shots in a minute; each loom is independent, making from thirty-six to fifty yards per day, and one girl tends eight looms.

But the most notable improvement is the absolutely successful achievement of weaving the very highest class of dress gros-grains, black and coloured, by power. This has been accomplished by the Messrs. Simon, at Union, New Jersey, about fifteen miles from Paterson. Mr. Simon, educated as a civil engineer in the technical schools of Europe, has combined the various improvements observed by him abroad and in this country into an automatic loom; upon which, with the attendance of a boy of twelve or fourteen years old, sixteen yards of broad gros-grain silks may be woven per day,—the cost being eleven cents per yard. The production of eighty looms in this establishment has this average. We are assured that no first-class goods are woven abroad by power. These goods can therefore be made more cheaply here than at Lyons. These looms, with their products, won the admiration of our associate, Mr. Gebhard, who remarked "that he had never seen such goods made upon power-looms, and had no idea that such work could be performed automatically."

Silk Braids, Trimmings, and Laces.—This department of the silk-manufacture employed in 1876 two thousand seven hundred and fifty-three operatives; more than three-fifths were women. The founder of this branch of industry in the United States—if, indeed, he may not claim to be the pioneer of the industry as a whole—was William H. Horstmann, who, having learned the trade of silk-weaving in France, established himself in Philadelphia, in 1815, as a manufacturer of silk trimmings. In 1824 he introduced from Germany the use of plaiting or braiding machines; and, in 1825, the use of the first Jacquard loom employed in this country. By means of the various improvements introduced by him and his successors, his sons and grandsons, the house of William H. Horstmann & Sons has become one of the largest in the silk-manufacture now existing in this country. Its vast warehouses and sale-rooms in Philadelphia bewilder the eye with the number and variety of fabrics; including, indeed, the whole range of narrow textile fabrics,—bindings, braids, fringes, dress trimmings, coach and military equipments, theatrical goods, gold and silver laces, and embroideries. Two other large houses in Philadelphia, viz., J. C. Graham, and Homer, Colladay, & Co., vie with the older house in the production of this class of goods. Their houses were established about 1850. These manufacturers have most contributed to give Philadelphia its reputation as the chief seat of the general manufacture of trimmings in the United States. In New York, the present house of J. Maidhoff & Co. was established in the manufacture of dress trimmings in 1849. In this city, Louis Franke is also promi-

nently identified with the manufacture of silk fringes, cords, and tassels. In Connecticut, Tobias Kohn, of Hartford, now president of the Novelty Weaving and Braid Works, established the manufacture of gimps, fringes, and tassels as early as 1848. An expert in this department of the silk fabrication observes that "the home manufacturers so fully supply the demands for the dress-trimming trade that there are very few coloured dress and cloak trimmings imported. The variety of patterns for sale at the trimming stores is so great that ladies find no difficulty in perfectly matching the colour of their dresses. While thus meeting all the requirements of taste, the American fringes and trimmings are in general of the best material. Being made of pure silk, they will usually outlast the garment they ornament. They contrast in this respect with imported goods of similar appearance, but made from inferior silk, and hence apt to fade from exposure, or to wear out and fall off. Greater care in the processes by which they are made has also contributed to the notable superiority of American trimmings."

The manufacture of silk laces by means of the most modern and approved European machinery has been undertaken on a large scale, with high success, by A. G. Jennings, of the Nottingham Lace-Works, Brooklyn, New York; the machines made in England having cost over one hundred thousand dollars. The products of the works are principally silk guipure laces, and black thread and silk blonde laces for trimmings, Brussels spot-net and grenadine veilings, silk purling for trimmings, and silk-lace ties and scarfs. It is claimed that the lace goods are superior to those ordinarily imported, from being made of pure silk. The exhibit of these goods at Philadelphia received an award for excellent fabrication, and for "illustrating an important manufacture just introduced into the United States by the exhibitor."

General Observations.—Having considered the characteristics of the three leading departments of the silk manufacture in this country, our remaining observations must apply to the industry as a whole. It is believed that, as a whole, American silk machinery, in efficiency, is equal, and in some respects superior, to that abroad. As to our fabrics, first in acknowledged excellence are our machine-twists and sewing-silks, articles of first necessity in the manufacture of boots, shoes, and clothing, and in the household economy of every home. The machine-twists are produced of such quality and at such prices as entirely to prevent the importation of foreign twists, and sewing-silks are imported only to satisfy the lingering prejudice against domestic productions. Our spun-silk fabrics have no foreign rivals, in quality and prices. In ribbons, we supply two-thirds of the demand of our own market, and in plain goods can fairly compete in quality with the products of St. Etienne. In trimmings, even with their infinite diversity, there is no article made abroad which is not or may not be reproduced here. In broad silks, each of the last five years has seen the achievement of some new fabric, advancing from millinery to dress silks, overcoming all the difficulties of Jacquard weaving, and thence to brocade and damask silks. Our manufacturers have in the last year seen accomplished, on a large scale, the fabrication of coloured and black gros-grain dress-silks, which are pronounced, not by the makers, but by rival manufacturers, to be absolutely equal in quality, while cheaper in price, to the very best imported silks. We are still, however, far from the position in the silk-manufacture to which we should aspire. In the higher fabrics, we are wanting in originality, and a national character of design. The widest field for artistic work, that of the fabrication of upholstery stuffs, is almost wholly unexplored. We have made no bolting-cloths, have done nothing in velvets, and still allow the silk plushes for hats (so enormously consumed here) to be made abroad. With all the excellences of our machinery, we are too dependent upon foreign workmen for skill in manipulation. Technical and art schools, which shall develop native taste and skill, can alone give a national character to the higher fabrics of this industry.

These general observations cannot be more appropriately closed than by a summary of the American production, as furnished by that model industrial institution, the Silk Association of America:

VALUE OF PRODUCTS, CLASSIFIED BY ARTICLES, MANUFACTURED IN THE YEAR ENDING DECEMBER 31, 1876.

	Pounds.	Value.
Tram	369,132	$2,768,490
Organzine	184,567	1,614,961
Spun silk	140,000	805,000
Fringe-silk	33,862	203,172
Floss-silk	5,488	35,428
Sewing-silk	82,895	951,460
Machine-twist	468,916	6,301,059
Dress goods	—	1,350,535
Millinery and tie silks	—	1,679,166
Women's and men's scarfs	—	119,946
Handkerchiefs	—	927,000
Foulards	—	472,000
Ribbons	—	4,526,556
Laces	—	220,000
Coach laces	—	24,500
Veils and veiling	—	16,518
Silk hose	—	3,200
Braids and bindings	—	315,000
Military trimmings	—	28,000
Upholstery trimmings	—	526,036
Ladies' dress trimmings	—	3,705,076
Total products, 1876	1,284,860	26,593,103

	Pounds.	Value.	
Reeled silk consumed	1,144,860	$11,874,570	
Spun silk consumed	140,000	805,000	
Total silk threads	1,284,860	12,679,570	12,679,570
Consumed in sewings and twist	551,811	7,252,519	
Consumed in weaving	733,049	$5,427,051	$13,913,533

The American Exhibits of Silk.—Although much material furnished by the Exhibition has been incorporated in the preceding pages, the features of the display of products of the silk-industry at the Exhibition demand a special notice.

The position accorded to the American silk exhibits was an exceedingly advantageous one. Instead of being thrust on one side or into a corner, it had the post of honour at the east end of the Main Building, on the central aisle; and thus naturally attracted the first attention of the visitors who made a systematic survey of the Exhibition. The show-cases in which the goods were displayed exhibited the good taste so peculiarly requisite in this industry. Although various in construction and ornamentation, there was a general resemblance, which gave agreeable unity to the display. Inside the cases some of the goods (as those of spooled silk) were arranged in architectural devices, giving the effect of towers, domes, and arches. In others, the richness of fabrics alone sufficed to give brilliancy to the displays. The arrangement of the dyed silks, so as to give prismatic effects, was peculiarly attractive. No visitor could fail to feel that, if this exhibit had been wanting, the American display of textiles would have lost its chief charm, and American patriotism one great source of its complacency. In Machinery Hall, and in the Women's Pavilion, different processes of the silk manufacture were illustrated, on a large scale, by several different manufacturers. The actual operations of reeling, twisting, spooling, and weaving—in some cases by the Jacquard attachment—gave delight and instruction to curious throngs. The newest American machinery—especially the "two-decker" spinning-frame, constructed by the Danforth Locomotive & Machine Company, containing winder, doubler, spinner, and reeler in one—attracted the admiration of experts.

These exhibits were equally surprising to foreign visitors and to our own people. High tributes have already come back to us from abroad: the French publicist, Jules Simonin; the Swiss Commissioner-General at the Exhibition;

and a well instructed writer in a paper published in Macclesfield, the head-quarters of the English silk-industry,—having pointed out the exhibits at Philadelphia as proofs of the competition which their countrymen must expect in this country.

Having given the names of the principal foreign exhibitors in this department, we cannot do less for our own countrymen. In describing the exhibits, to avoid any possibility of error, the writer has adopted substantially the language of the official awards. The exhibitors are grouped according to the departments they pursue, and are named irrespectively of merit,—no numerical scale of excellence being admitted by the rules of the Exhibition:

J. H. Hayden & Son, Windsor Locks, Conn.

Slack and medium twist, of great brilliancy, strength, and regularity.

M. Heminway & Son, Watertown, Conn.

Machine and sewing silks, perfect in quality of material, colour, and workmanship.

Holland Manufacturing Co., Willimantic, Conn.

Machine-twist and sewing-silks; highly meritorious for the excellent quality of raw material, and the preparation for the various purposes.

Seavey, Foster, & Bowman, Boston, Mass.

Sewing-silks, of great uniformity and general excellence.

Belding Brothers & Co., Rockville, Conn.

Machine and sewing silks, of good colour, strength, smoothness, and quality.

Aub, Hackenburg, & Co., Philadelphia, Pa.

Sewing and embroidery silks, meritorious for great beauty and brilliancy of colour; button-hole twist and saddler's silk highly commendable.

Nonotuck Silk Co., Florence, Mass.

Sewing-silks and machine-twist; great superiority as to strength and regularity, evincing extreme care in the manufacture.

S. M. Meyenberg, Paterson, N. J.

Millinery silks and upholstery satins, of superior quality and finish; ladies' scarfs, of excellent colour and design.

John N. Stearns & Co., New York, N. Y.

Brocade silks, of superior styles and quality; twilled silks, well made, and meritorious in every respect.

Dexter, Lambert, & Co., Paterson, N. J.

Millinery silks, well made, and of good colours; brocade silks, of excellent manufacture.

Cheney Brothers, Hartford and South Manchester, Conn.

Spun silk, in every form, perfectly manipulated; piece goods and ribbons made thereof, evincing a high degree of excellence.

New York Woven Label Manufacturing Company, New York, N. Y.

Woven silk labels and *fac-simile* of signature of Declaration of Independence, of good execution.

Frederic Baare, Paterson, N. J.

Black figured silks, made in an improved and superior manner; millinery goods, of good manufacture.

Hamil & Booth, Paterson, N. J.

Figure, dress, and millinery silks, plain satins, serges, and silk ribbons, of excellent manufacture and material.

Werner, Itschner, & Co., Philadelphia, Pa.

Faille, fancy, and Jacquard ribbons, of very good manufacture both as to colour and combination of material.

B. B. Tilt & Son, Paterson, N. J.

Brocade silks and handkerchiefs, of superior quality and workmanship.

WILLIAM STRANGE & Co., Paterson, N. J.

Plain and fancy ribbons, of good materials, well made in every respect; silk and millinery ribbons, of great beauty and superior quality.

LOUIS FRANKE, New York, N. Y.

Silk fringes, dress trimmings, and tassels, of the best material, excellent in style and manufacture.

SUTRO BROTHERS, New York, N. Y.

Braids of great regularity and excellent manufacture.

DALE MANUFACTURING COMPANY, Paterson, N. J.

Silk and mohair braids, fancy cords and trimmings, of great beauty and excellent workmanship.

WILLIAM H. HORSTMANN & SONS, Philadelphia, Pa.

Dress, carriage, and upholstery trimmings, of great excellence and beauty in style, material, and execution.

A. G. JENNINGS, Nottingham Lace Works, Brooklyn, N. Y.

Guipure, cashmere, and other lace and trimmings and net goods, of excellent fabrication.

WEIDMANN & GREPPO, Paterson, N. J.

Black and coloured dyed silk; compares well with the production of the best European establishments.

Exhibits of American Cocoons and Raw Silk.—Although we have waived the consideration of the foreign products of raw silk, the only two American exhibits of this material were so interesting and instructive that they deserve an extended notice. While the silk culture has ceased in all the older States, it has recently been attempted, with sanguine hopes of success, in California and Kansas.

The planting of mulberries for the feeding of silk-worms was first undertaken at San José, California, in 1856, by M. Prevost, a botanist from Normandy, France; but the public attention was then so occupied with gold mining that the trees were unsaleable, and M. Prevost abandoned their culture. A small number of trees was also planted by a Swiss gentleman,—M. Mueller, of San José,—who, in 1861, imported a few silk-worm eggs. The worms raised were fed upon the trees before planted, and the results obtained were so excellent as to revive the interest of M. Prevost, who recommenced the planting of mulberries and raising of silk-worms, which he continued until the time of his death, in 1869; he having in the mean time distributed silk-worm eggs, gratuitously, to persons in various parts of the State. The interest in sericulture thus became so general in the State that the Legislature of California provided by law that a bounty of $250 should be paid for every 5000 newly-planted mulberry-trees, and $300 for every 100,000 cocoons produced in California. The object of the law was defeated by the planting by speculators, for the bounty, of several millions of the worthless multicaulis mulberry, and the law was repealed. In 1866, Mr. Joseph Neumann, of German birth, imported machinery for the fabrication of silk, and invented a reeling-machine for winding the raw silk from the cocoons. In 1867 he reeled the first skein of raw silk produced in California. In 1869 he produced 130 pounds of raw silk, and made from it two large flags,—one of which he presented to the State, and the other to the National Government. Meeting, like most pioneers, with but little commercial success in his attempts to manufacture silk, he finally abandoned the fabrication for the production and reeling of raw silk. His very large exhibit of cocoons and raw silk, and his exhibition of worms feeding and in different stages of growth, attracted great interest, and received from the expert Judges the following award: "A very good collection of "cocoons and raw silk, of a variety of races, highly commendable for the suc- "cessful attempts in the introduction of this important branch of industry."

The statements made by Mr. Neumann to the Judges, in regard to inducements for sericulture in California, were so interesting and important that they deserve a wider publication.

He regards California as better adapted for the silk-culture than almost any country in the world. He said, in regard to climate, that—

"The mulberry-trees in most parts of the State grow ten months in the year (from February to the end of November); so that worms can generally be fed uninterruptedly. Spring, summer, and fall are uncommonly dry, consequently the food of the worms is dry. The mulberry-tree throws out new branches and leaves four times a year, and worms can be fed from the fifteenth day with branches. In some localities in California trees five years old surpass those of fifteen years in Europe. The leaves are much larger, also, and one can gather six or eight times as much as in Europe in the same time. Thunderstorms do not occur during the feeding-season, and the worms consequently are not disturbed. The dryness of our atmosphere prevents the remains of the leaves which the worms do not consume from decaying, and the beds need not be cleaned more than twice in a season. We have proved that the cocoons enlarge from year to year."

In Kansas, sericulture has been attempted by E. V. de Boissiere, a French gentleman of means, who has set his heart upon surrounding his chosen home with a colony of operatives employed in the silk-culture and manufacture. He has built a mill for the manufacture of silk goods, and is confident that the silk to supply it will be produced in his neighbourhood. His exhibits of raw silk and cocoons at Philadelphia were conclusive as to the favourable influences of the soil and climate of Kansas for sericulture. The remarkable character of the cocoons exhibited by M. de Boissiere so much impressed Mr. Le Boutillier, one of the American Judges of silk in Group IX., that he requested Mr. Hayami Kenzo, of Japan, a member of the group specially expert in raw silk, to give him his personal observations. Mr. Kenzo thus replies, in a note to Mr. Le Boutillier, now before the writer:

"Having examined the cocoons from Kansas, we marked them as good as the best cocoons from France, Italy, and Japan. Having a doubt as to the correctness of our judgment, I looked them over again with great care, and came to the same conclusion as we had before. I suppose the mulberry-trees are cultivated in very rich soil, and, being not so old, are especially suited for feeding silk-worms. The chrysalids are large and healthy, and several have been almost entirely transformed into butterflies. The best silks in good weights will be obtained from these cocoons."

It is obvious that a protective duty on raw silk for the general encouragement of sericulture in this country would not be justified. The culture offers no prospects of success, except in a few favourable localities; and a duty on the raw material would be oppressive to the manufacture. The question of encouraging the silk culture by legislative provisions addresses itself only to the governments of the States which are specially adapted by soil and climate to this culture. The American Judges in Group IX. were so impressed by the exhibits and facts presented by Mr. Neumann and M. de Boissiere, that they were prepared to indorse memorials which might be addressed by these gentlemen to Legislatures of their respective States, asking for bounties on silk productions. The members of the group, however, separated without taking more definite action in this matter.

In concluding the report on wool, we gave the yearly production throughout the world. We cannot do less for the more costly material. The following statement, prepared by Mr. Franklin Allen, is believed to be a near approximation to the yearly production of raw silk in the several silk-producing countries of the world at the present time:

China and Chinese Empire	$92,928,000	Total, $267,553,400.
Japan	19,800,000	
Persia, Turkistan, &c.	6,250,000	
Syria and Asia Minor	8,500,000	
Italy	59,250,000	
France	31,246,800	
Turkey in Europe	7,920,000	
Spain and Portugal	1,884,000	
Greece	1,087,000	
Morocco	300,000	
Austria-Hungary	3,087,600	
India	35,200,000	
America	100,000	

GENERAL REPORT

ON

GROUP XI.

JEWELLERY, WATCH-CASES, SILVER-WARE, BRONZES, &c.

JUDGES.

American.	*Foreign.*
Mr. Martin P. Kennard, Boston, Mass.	Mr. G. H. Heap, Tunis.
Mr. Peter Gottesleben, Denver, Col.	Mr. Roulleaux Dugage, France.

The following named Judge was temporarily assigned from Group XV. to assist in the examination of the classes attached to his name.

Mr. Julius Diefenbach, Germany.— Jewellery, silver and plated ware, fancy goods, gems, and enamel painting.

GENERAL REPORT.

JEWELLERY, WATCH-CASES, SILVER-WARE, BRONZES, &c.

The Judges of Group XI. were assigned a somewhat wide range of industries, their classifications leading them through varied productions of utility up to the Fine Arts. In gems, in gold and silver work, in artistic bronze, and in the enameler's and the lapidary's arts, the exercise of their judgment was called into a more diversified and difficult path than if they had been given any single and special manufacture, however extensive its relations.

They entered upon their labours at as early a day as possible, their number being at first incomplete, owing to the non-arrival of expected foreign members. Their work was attractive, however, and their action always harmonious. They had their surprises and disappointments,—the former at the delightful and varied affluence of such exhibits as those of Russia and Japan, the latter at the scantiness of the French section in comparison with French ability, and the absence from the United States department of many of those workers in the precious metals who, in their supply of the American trade, have distanced the world. It was fitting that more of these prominent manufacturers of gold and silver goods should have shown, through the courts of this Exhibition, the evidences of their genius and industries.

Jewellery.

In their absence the Exhibition failed to represent, particularly in the department of jewellery, the existing abilities of the country, and it is to be regretted that their places were filled by inferior representatives, many of whom, because located adjacent to the Exhibition, were enabled to occupy their positions at small expense. When we seek for the reasons for such absence, we suspect a disinclination to publicly display patterns, where so little respect is paid to another's property in any novelty of design, and where the recording and protection of trade-marks seem not yet to have been set up as established rules of the trade.

It may also be said that the more important manufacturers have often their own peculiar trade; and the markets for their goods, and in some cases their patterns, are controlled by their various customers, the merchants, to whom they confine themselves, for mutual advantage. To these drawbacks may perhaps be added the depressing influences of two disastrous years, unexampled for their detriment to this trade, and in consequence a large and general reduction of force, and falling off in the production of novelties. It is proper to say here, however, that the better examples—though few—of American jewellery equalled those of any other nation as to display of taste, mechanical execution, or quality of material. They are better adapted to American demands, and the evidence of this is in the small quantity now imported. American gold chains and necklaces, also collarets and band bracelets in the Roman and Etruscan manner,—styles now in vogue,—are specially notable as of admirable character, and none exceed them for beauty of design or workmanship. The same may be said of lockets, and has been said of our gold and silver watch-cases for years past.

Without entering into dry statistics, it may be interesting to mention that, according to the data of 1871, the last year of the war tax, the jewellery manufacture at Newark, New Jersey, alone, upon which that tax was paid, amounted to eight millions of dollars, and in the city of New York, the same year, it was between six and seven millions. The number of working jewelers in the United States is estimated at twenty-five to thirty thousand; of these Massachusetts has about fifteen hundred; Rhode Island, chiefly in the city of Providence, twenty-five hundred; Newark, New Jersey, about sixty establishments, and nearly twenty-five hundred workmen; and the city of New York about six thousand workmen. In some of the jewellery manufactories are employed, in ordinary times, from three hundred to four hundred men. There are also in the United States about twelve thousand watch and jewellery stores of importance. Connected with these is always a force of watch-repairers and working jewellers adequate to the business of each individual establishment.

In the present stagnation of a trade which is especially sensitive to times of depression, there has followed, of course, a marked reduction in the volume of business; to what extent it is now very difficult to reach conclusions with any degree of accuracy, nor is it essential here.

Silver-ware.

In the precious metals, however, it was manifest that our chief strength was in silver-ware, for which America has made large demands in late years; indeed, the displays of American silver-ware excelled all others, and were among the distinguished attractions of the Main Building. It is evident that the great production of this metal, and the unprecedented demand for silver utensils in the United States, have stimulated manufactures in this branch of mechanical art, and that a growing æsthetical taste insists upon the highest possibilities. Without aspiring to the exhibition of marvellous essays of human ingenuity and artistic skill, which, when completed, are only monuments of the patient and inexhaustible labour of some gifted and exceptional artist, and void of real utility,—if we except a few prize and race cups, and one or two more ambitious testimonials and symbolical centre-pieces, or vases,—the American silver exhibits were generally more practical in character, artistic in detail, of higher elegance, and of superior grade of work. We should note also, from several important establishments of the United States, distinguished examples of the "hard," or silver-soldered and electro-silver-plated upon nickel or German silver ware, for table and general domestic use, especially praiseworthy for enduring quality, finish, and good taste; indeed, no better goods of this class were on exhibition than some of these specimens.

In the soft metal, or tin-soldered ware, known as plated upon Britannia-metal goods, for like domestic purposes, there was a liberal representation of a large and extending industry. Since the development of the electro-plating process, this peculiar metal trade has obtained more prominence in the United States than even in the English markets. From its facility and cheapness we have more manufacturers and consumers of this ware than any other nation, and our products in this branch of metal-work are finding a considerable demand from abroad. There is need, however, of a higher standard of design. With but few exceptions, our goods of this character lack simplicity and soberness of decoration, and more attention to outlines and beauty of form is desirable.

It may be answered that this is cheap ware; but with metal so facile it need not lack taste in shape, or be inartistic or vulgar. Too many of the examples were marked by a garish taste, a prominence of ornamentation void of significance, and a profusion and confusion of ungainly bodies, handles, legs, and spouts, a jumble of materials often incongruous, without unity, elegance, or originality. There was also too much suggestion of traditional styles, and a kind of mill-work that is monotonous. If the uncultured of our Western frontier trade demand the meretricious, it does not follow that the taste of these people need be further perverted by coarse designing. As in many other manufactures, it is time we had an art and a series of patterns more distinctly our own, and that our productions in this metal should not always suggest to those at all conversant with the trade the débris of the Sheffield and Birmingham work-shops of former days. The character and quality of these goods may be deemed honest for the price, and our technical processes are well advanced; but an improvement in styles must be sought if it is desirable to augment foreign demand, or reap that harvest in the markets of the world to which metal-ware of such popular utility is entitled.

In the line of electro-plated flat table-ware, known as rolled goods, viz., knives, forks, spoons, and numberless pieces of a kindred nature, there is an immense production in the United States. These forks, and in some cases the knives, have superseded the ivory-handled goods so liable to crack in our dry climate and with our indifferent domestic service. A set of steel dies or rolls for making a suite of these goods of each pattern involves no inconsiderable outlay, and but a few years since only a few patterns were in use. Then the London market could only furnish the "king's pattern," the "shell pattern," the "thread pattern," and perhaps one or two others, and these were made mostly in solid silver. Now there are many American manufacturers who furnish a greater variety of their own designs than were then extant, and absolutely compute their production in tons rather than by the gross.

It may be germane in this connection to allude to the difficulty experts or others experience in determining the quality of electro-plated articles. It was at this point that the Judges were sometimes compelled to hesitate in characterising quality. The amount of silver deposited is often one of the trade mysteries. The only conclusive test would have been to "strip" or assay in their presence such doubtful articles, and thus to determine the exact amount of silver, as also the quality of the nickel-silver basis upon which the silver is deposited, which is not feasible in such an Exhibition. At the manufactory such are weighed, in and out of the plating process, and if there be six or sixteen ounces upon the work it is manifest in the scales, and there only; so that much has to be taken for granted, and it is easy for unscrupulous manufacturers to foist poor goods upon the market.

Nickel-Plating.

Nickel-plating by the electro process is slowing making its way to meet the requirements of our domestic life. Being somewhat grayer in colour, it perhaps may not be so popular with the housekeeper as the acceptable whiteness of true silver-plating, yet it has some advantages unknown to its more aristocratic rival. With a relative cost of about one-fifth less than silver-plating, it presents a harder surface, less liable to be defaced, does not oxidise under the action of impure air, and therefore requires less care. For hotels, hospitals, and ship and steamboat use the exhibits of this ware impressed the Judges for their economy and service. In the earlier stages of electro-plating the electro-deposition of nickel was found to be more difficult than the other metals. It did not uniformly adhere, and was treacherous and uncertain in its action. To obviate this, in some cases it was found needful that the article to be plated be first given a slight coating of copper, as for this metal the nickel has a more ready affinity. The whole difficulty, however, was at last overcome by the discovery of the process patented by Dr. Isaac Adams, Jr., in Boston, Massachusetts, in 1869. It has augmented the use of this metal for plating purposes, and, as the method was not known previously, it is practically an American art-industry. The ordinary nickel-plated hollow-ware is upon a basis of planished tin, or of Britannia metal, and also upon "nickel-silver"; but this coating with nickel enters into other and manifold purposes, and renders it an important factor in the utilization and improvement of metal-work for household use, and in a broad field of other service.

Bronze of Art.

In the production of true bronze, known as the bronze of art, saving a colossal marine group for the Lincoln monument at Springfield, Illinois, from the Ames Foundry at Chicopee, Massachusetts, and a few ornamental pieces and decorative mountings for marble mantel-clocks wanting in originality, the American sections gave but little evidence of vitality. Our art-life in America has been short, our historic figures few, and our art museums as yet meagre in examples for study or for repetition. In this branch we depend upon European copies and reductions from the classic models of Greek and Roman art. The time is coming when our native birds and animals will be thus modelled and preserved; and there are many incidents in our civil, our military, and our Indian history which furnish admirable examples for illustration in enduring bronze, and may thus be perpetuated in objects of household art. We need the educational influences of such depositories as the Kensington Museum in London, or the Louvre in Paris, to stimulate the imagination and inspire the taste and action of our artisans in such metal-work as well as in other branches.

Imitation Bronze.

There were also a few examples of zinc imitations of art-bronze objects, the models chiefly copied from the French makers. These are cast whole as a "cone," and painted and coloured superficially, or covered with an electro deposit of copper, and then artificially bronzed to simulate the genuine at comparatively little cost. It may be said here that the public do not always discriminate between this work and true bronze. Such are advertised, and often sold as bronze, and sometimes as "French bronzes,"—perhaps not always with deceitful intent,—whereas they are but brittle spelter or zinc, and bear

no more relation to the real than a coarse chromo does to an original oil painting. This is, however, a new and growing branch of metal-work, and, with enterprise and good taste, will find ample compensation and a large field.

Great Britain.

The labours devolved upon this group by exhibitors from Great Britain were not arduous. There were representations from London, Birmingham, Liverpool, Edinburgh, Belfast, and Dublin, the most important of which was the distinguished and comprehensive exhibit of solid silver and electro-plated metal-work by Messrs. Elkington and Co., of Birmingham. This establishment maintained here its distinction for the high character of its artistic work in metals. Their samples ran through the whole gamut of the trade, from articles for simple domestic purposes up to their most ambitious productions, some of these being veritable art pictures, and apparently the culmination of human ability in metal work, the excellence of which has been acknowledged in former Exhibitions. Among the branches of this industry more recently developed by this house is that of damascening and inlaying of various metals, the specimens of which were admirable novelties; also, a simulation of the better examples of Japanese work in incrustations, both ingenious and complete; with, also, the processes both of cloisonné and champ-levé enameling, only recently introduced into Europe from the Eastern nations. Their displays in this decorative and artistic work were unrivalled for freedom of design and quality of colour and finish. The horological portion of the English section was liberally represented by the best of the English trade, there being many familiar names of great repute among the watch exhibitors, both from London and Liverpool. For the treatment of this department, as to chronometric qualities, reference is made to the report of Group XXV. The other British exhibitors displayed chiefly miscellaneous contributions, but were notable also as representing such specialities as manufactures of Scotch pebbles set in silver as jewelry, bog oak carvings and ornaments, Whitby jet goods, and the like, in their peculiar provincial individuality. They showed also admirable examples of jewelers' work in gold and gems, but generally of that conventional and massive-appearing character which does not now find a responsive taste or a market in the United States.

Russia.

Russia presented to the attention of the Judges an admirable and profuse display of fascinating examples of her manufactures in gold and silver, in fine bronze, and in articles made of Russian ornamental stones. There were many novelties in her court that were a revelation to an American. The remarkable silver-ware so amply displayed by Sazikoff and others, both from St. Petersburg and Moscow, with specimens of repoussé and chiseled effects, and the peculiar representations of linen and damask in this metal, with the radiant beauty of the gem-like enameling upon gold and silver and gilded silver utensils in Greek, Byzantine, and Russian taste, were such marvellous illustrations of the capabilities and truly artistic fancy of Russian artisans as would have awakened the enthusiasm of a Benvenuto Cellini and that of the historical Palissy, the famed enameler of Limoges. There was much of ingenious and pleasing caprice in the novelties in silver and in the gold jewelry and niello-work that were suggestive to the American workers in the precious metals. The jewelry by Adler, of Moscow, being of gold mosaic or damascene work, with the metal of varied alloys and colours so combined and welded as to produce delicate effects with different grades of shading, was an original and decided novelty. The bronzes from Felix Chopin, from St. Petersburg, by the artist Lanceré, though few in number were refreshingly original, of native subjects, so well modeled and of such artistic delicacy and expression as to add lustre to this inviting section, and always find appreciative observers. An attractive specialty of Russian art is the working by veneering or inlaying of such of their ornamental stones as malachite, lapis lazuli, labradorite, etc., into articles for personal ornament, and also for luxurious furniture, as mantels, tables, vases, and smaller objects of household decoration. There are many of these that were strange and attractive, showing skilful work, and, in their peculiarity, unexampled in the Exhibition.

China.

The Chinese department was conspicuous for a large and interesting collection of decorated enamel utensils, vases, and ornamental articles in the cloisonné manner, both of ancient and modern Chinese work, for which the Commission were indebted to the consideration and generous public spirit of Hu Kwang Yung, a high official and banker of Hangchow. This section contained also various and curious bronzes, mostly of ancient and grotesque character, with some specimens of silver-work and gold ornaments by native artisans that were characteristic, though without especial claim to novelty.

Japan.

Japan gave us an imposing display of great excellence, and a gratifying surprise, in the remarkable bronze productions which were so attractive for their diversity and elaborate richness. In form, composition of metal, inlay-work, casting, chiseling, and ornamentation the Japanese have in general not only a distinct art and character, but each of their artisans, as illustrated by this Exhibition, seems to maintain an individuality, taste, process of composition, and, indeed, a peculiarity of metal distinctly his own, evidencing an extraordinary versatility, and a distinctive independence which our own metal-workers would do well to emulate. Their exhibits which came under the attention of the Judges of Group XI. were principally ornamental or decorative objects in bronze, as vases, censers, garden or temple lanterns, and jardinières, including also some delicate tea and other table-ware suggestive, in some respects, to our own manufacturers, and worthy of attention. The Japanese are adepts in alloys and in applied decorative combinations of gold, silver, and copper in incrustations, and in ingenious management of party-colours. In these metals they illustrate a luxurious prodigality of fanciful invention, which is in marked contrast with our own poverty in this branch of artistic metal-work. But however rich in fancy these examples of Japanese industrial art may have been, they were not uniformly so good in the mechanical qualities. They were often lacking in symmetry and mechanical perfection. Their pairs of vases, for example, were not always uniform in shape, being imperfectly matched as to measurements and relative proportion, a quality which with us is produced by turning-lathes and other engines of our own unerring mechanism, evidently not at present availed of by the Japanese artisans. In the vitreous enameled metal-ware, known as the cloisonné, they showed but comparatively few examples, and these, however elaborate and painstaking, were often deficient in the treatment and in the purity of their enamel, and weaker in the quality of colour than the best English specimens of this art. The Commission are especially indebted to M. Marunaka, of Kanazawa, province of Kaga, for many valued contributions to the Exhibition, which, however, being of a collective character, the regulations do not permit this group to further recognise with an award.

France.

France, as compared with other nations, sent us a goodly number of representations; but when we recall her fertile artisans and the ramifications of her many industries, when we remember that she leads the world in artistic and purely ornamental metal-work, in decorative furnishings, and in all articles of luxurious fancy, we are constrained to believe that her resources were not adequately represented in our Exhibition. One recognised at intervals some of her best productions, and yet found they but insufficiently suggested the manifold attractions of Paris. There was a dearth of those attractive Parisian specialties for which the United States have been such ready customers; and in those faithful mechanical reductions in bronze of the many historical subjects and classical remains of antique art which would have been of great interest, the paucity of the display was much to be regretted. In point of fact, many establishments prominent for their productions in bronze were unrepresented. In ware electro-plated with silver, and galvano-plastic articles for domestic use, there was also a palpable dearth; yet the French department was an extended and attractive one, of such great variety that it should not be underestimated. Their gold-workers presented some notable examples, Boucheron

and others, of Paris, displaying superb productions of rich jewelry with rare gems and brilliant enamels. These contributions illustrated many periods, and, whether in obedience to the exacting extravagance of modern demand or in the faithful rendering of the best of the Roman or the Egyptian age, were of the very highest artistic and material merit. This section was also diversified with attractive exhibits of bronze, brass, and gilt art-work, champ-levé enameling, portable and mantel time-pieces, and mantel and other rich furniture. Marchand exhibited a remarkable chimney-piece of Greek style, with a central figure of Minerva in bronze, which was a masterpiece in its way. This section was also rich with palatial furnishings, by Cornu & Co., of Algerian onyxes and variegated marbles tastefully mounted in bronze. There were also collective reproductions of small antique objects in bronze of Pompeian character, and numerous other branches of Parisian fantasy, many of which, being imitations and of a finical character, were not inspiring acquisitions.

Germany.

From Germany there were many representations of those industries whose classification brought them to the attention of the Judges of Group XI. These included several with productions in silver for household service, of original and attractive character, and unlike any other examples in the Exhibition. There were also galvano-plastic or electrotype copies of those remarkable silver utensils and *paterœ* of ancient Rome known as the "Treasures of Hildesheim," in solid silver and in baser metal, interesting not only as exact repetitions of high art work, but as valuable illustrations of the advantages of this process of depositing by galvanic action, and thus precisely reproducing the most elaborate work. The German manufacturers made a good display of electro-plated wares, and their oxidized silvered goods gave evidence of more attention to productions of this specific character than appeared in other sections. Some two or three manufacturers exhibited copiously of galvano-plastic and zinc composition, models of monuments and public characters in German history, in the manner of real bronze, the casting followed with a superficial covering of copper, and then bronzed or coloured, which were rather inartistic in character and devoid of sharp and expressive outlines, but of moderate cost. Perhaps the most noticeable feature of the German department of the Main Building was the jewellery and gold-work. There were several interesting collective exhibits which included the productions of many combined manufacturers. These were chiefly from Hanau, Pforzheim, and Swabian Gmünd, for many years the homes of much of this industry. All the grades were here, from the better examples of European work (but mostly of the fourteen-karat quality) to the lightest and the cheapest adaptations to the requirements of their specific markets. It may be inevitable from familiarity, but one who is in any degree conversant with these goods is inclined to wish for more frequent departures from long-wonted styles. A stray scholar from some school of design should be acceptable to some of these manufacturers; fresher ideas and new dies would be less suggestive of automatic work, and perhaps bring needed flexibility and a livelier trade. France and Germany have of late years drawn away from Italy much of the business of cameo-cutting. In this art there was a collective representation, with some excellent specimens from Idar-Oberstein, the present location of much lapidary and glyptic industry.

Italy.

The Italian department was somewhat barren of the best samples of Italian ability. With the exception of praiseworthy examples of fine jewellery and gold-work by Bellezza, some fascinating reproductions of the Greco-Etruscan period by Castellani, silver filigree-work from Genoa, a little really fine coral from Naples, and a few artistic bronzes of classic mould,—statuette reductions from the antiques by Boschetti, of Rome,—it gave us little of striking importance, and but the average of the sales-rooms and the shops of Florence, Rome, Naples, and Genoa. This section bore rather the character of a bazaar than of an Exhibition, and it seemed evident the exhibitors had thus calculated. There are many attractive specialties of Italian art that are inviting to the stranger which were looked for in vain. In a word, they gave us copiously of their merchandise, but not much of their most esteemed art.

Austria.

Austria sent us specimens of her fine jewellery and some admirable gold-chainwork, with imitation jewellery and false stones of many sorts; also, many examples of small gilt and bronze metal articles of varied fancy and purpose. These chiefly came from Vienna. There was also a liberal display of the Bohemian garnet jewellery, a peculiar manufacture of that province. These stones are set in a red composition of copper and gold, and when thus mounted are of moderate cost. At times these ornaments have been an important element of trade, and now, for almost an indefinite period, have come to us without material change of patterns. If those interested in this manufacture desire the business to survive in the American market, it would be advisable to stimulate it with some new ideas and designs.

Switzerland.

Switzerland displayed some superb jewellery and gold-work, and also exquisite enamel paintings set as jewelled ornaments and pendants, especially noticeable; and her ingenious artisans here maintained their renown for fine watches of many styles, with skilful engraving and tasteful ornamentation in decorating and casing them.

Norway, Denmark, and Sweden.

These countries each presented interesting contributions, but mostly manufactures of silver. The silver filigreework from Norway was of distinguished excellence.

Portugal.

Portugal also gave us several exhibits of silver-work, chiefly of filigree ornaments of mediocre character.

Egypt.

To the Egyptian National Museum we were indebted for specimens of Egyptian industry in gold and silver filigree.

Belgium.

Belgium illustrated the value and quality of her black marble, in examples of decorated mantel-clocks, with movements of French manufacture.

Spain.

From Spain the only exhibitor who claimed the attention of the Judges of this group was P. Zuloaga, of Madrid, whose specialty is the incrustation of metals, and who displayed caskets, vases, salvers, and many other articles of ornamental work in iron, enriched with gold and silver inlay and damascene work, rendering them quaintly ornamental and quite exceptional in character. This collection had the flavour of the mediæval age, and suggested an epoch when time was not money.

Tunis.

To his Highness the Bey of Tunis we were indebted for examples of Tunisian ornaments of various descriptions for personal wear, and of interest for their novelty.

India.

From India we had the interesting contributions of Messrs. Watson and Co., of Bombay, comprising rich gold and silver ornaments, skilfully made of filigree, and fine gold repoussé native work of remarkable character, with a utilization of tigers' claws neatly mounted in gold for feminine adornment; also, silver cups and other utensils exquisitely wrought.

Turkey.

Turkey, through her representatives from Albania, Trebizond, Aleppo, and other centres, exhibited many characteristic articles of rich fantasy, such as rich enamelled coffee cups, caskets, jewel-cases, and other articles of silver

filigree-work, Albanian niello enamel specimens, damascene-work in iron, with cutlery of Damascus steel, and various articles for personal ornament, Oriental in taste and of curious interest.

Brazil.

Brazil sent us a few examples of jewellery and manufactures of gold, with an elaborate display of her peculiarly brilliant insects, variously mounted as jewellery and decorative ornaments for personal wear.

It is to be regretted that some prominent exhibitors of rich jewelry and silver-ware were, by the needful regulations of the Centennial Commission, debarred from such distinctive awards as would have been commensurate with the admirable and meritorious character of their varied displays. Of those exhibitors, Messrs. Bailey and Co. and Caldwell and Co., of Philadelphia, and Messrs. Starr and Marcus, of New York, are conspicuous. Being merchant jewellers, their exhibits were of a collective character, including other than their own manufactures, and as such necessarily non-competitive, but their attractive sections cannot have failed in public appreciation.

Watches.

Watches were referred to Group XI. to be regarded chiefly from the ornamental and commercial point of view, their movements and chronometric qualities being left to the consideration of the judges of Group XXV.

The treatment of this subject leads one at once to the exterior attractions of this useful pocket mechanism. It is proverbially an ungracious privilege to be the recipient of the shells, while another regales himself with the luxurious bivalve; but, as sometimes the pearl of the shell is of more value than the meat, so it may be with—in this age—that very important companion of mankind, a watch: the case can be of more value than the movement. Dropping the metaphor, watch-case making in the United States has for nearly half a century been an important and increasing branch of gold and silver work. For the specific American trade American made watch-cases were preferable to foreign ones, because they could be better and more readily adapted to the exacting fancy and varied and independent tastes of Americans; and from the earliest introduction of this manufacture they have not suffered by comparison with foreign work. There was, besides, economy in avoiding an exorbitant tariff by importing only the watch-movements, and casing them here. With increased demands great improvements have been made in the technical processes of this work, the aid of novel machinery evoked, and the cost of production materially reduced, placing them at prices beyond all foreign competition.

Many watch-case making establishments now find employment for a large force, the most important of which are those connected with the several watch manufactories at present in operation; one of these, the Waltham (Massachusetts) Company, for example, having an average monthly product of 5,000 silver cases, and upwards of 1,500 gold ones. Nor are the results of this branch of manufacture produced wholly by the aid of machinery. It gives employment to numerous skilful artisans, as engravers, enamellers, and their like. The American watch-cases so copiously displayed in the Exhibition, for mechanical qualities, finish, decorative engraving, and varied ornamentation, were generally of the highest excellence, and also remarkable for their diversity of patterns.

In no department of the business during the present generation has there been a more radical change than in that of the watch trade, whether we consider the locality of the sources of supply, the character and the styles of the goods, or the mechanism and principles employed in the construction of the movements. In earlier times English watches well-nigh held the markets of the world. Within the last three or four decades Coventry supplied the cheap grades, Liverpool and Prescott furnished a better class of more trustworthy and substantial work, and the London makers produced chiefly the highest quality and most accurately adjusted mechanism. A London watch was then the synonym for a satisfactory time-keeper. Subsequently all these in a great degree yielded to the higher styles, more attractive, equally trustworthy, and more economical productions of the Swiss makers.

The lower grades of English work at first disappeared, their verge-escapements following the sun-dial and the clepsydra into desuetude, the Swiss watches supplanting them both in the United States and, to a great degree, in their own home markets. While the inferior English watch-work thus suffered, the Swiss makers were advancing with their improved escapements and tasteful and more inviting and diversified patterns of the very highest grades of complicated movements and adjusted work, which rivalled, and in some markets long since superseded, many of the best London names; so that, with the exception of a very limited number of well-reputed and exceptional makers, the demand for English watches has now ceased in the United States. Switzerland enjoyed for many years, without much interruption, the advantages of this large and profitable field, particularly as regarded the trade with America, but the present tendency is to an absolute reversal of former conditions.

In the march of events, and under the cheap production, mathematical precision, and interchangeability of parts of the watches now made by American machinery, the Swiss makers are sensibly feeling a diminution of American orders, and are preparing for the inevitable revolution foreshadowed by the acknowledged importance and perfection of the American system, so amply illustrated in the Philadelphia Exhibition. In point of fact, the United States, while ceasing to be customers, are becoming rivals, and are largely exporting watches in lieu of importing them.

It was the saying of an eminent London maker of former days,—whose various workmen of the many subsidiary trades needful in producing a watch under the old system lived away from him, and weekly brought to his establishment the varied detail of minute and delicate parts that went to make up the complete mechanism,—the jewellers, the escapement makers, the pinion makers, the springers, and the other numerous auxiliaries,—that "no watch would ever be properly and perfectly made until they could be wholly produced under one roof!" This point is now reached. From Nuremberg to Waltham it has taken four hundred years! Of the half-dozen watch manufactories at present operating in the United States upon this system, there were but two displays at Philadelphia, those of the Waltham (Massachusetts) Company and the company at Elgin, Illinois, the latter not being in competition.

In the earlier stages of American watch production the larger sizes were furnished, as being of the most popular character, and it was sometimes held against the machinery system that it did not permit such flexibility as to range of sizes as with the hand-made watches, where only six or twelve of any optional calibre were carried along together in the process of manufacture. This is now obviated, for the Waltham Company exhibited many sizes, ranging from the smallest useful sizes suited to ladies' wear to the maximum sizes for the use of gentlemen. As has been intimated, the popular American fancy has hitherto been for larger sizes than were used abroad. There is a perceptible change in this taste, and also in the demand for what are known as hunting-cases. The latter was greatly stimulated by the requirements during the decade succeeding the California exodus, so as almost to set a fashion, but they now seem likely to be replaced by the lighter and more convenient open-face finish. One of the most advantageous improvements of late years, for the convenience of the wearer and durability of the watch, is the invention of winding in the stem. Faulty at first, this admirable mechanism has been so perfected as to soon render all key-winders obsolete.

The advent of steam in travelling has generated a more rigid necessity for promptness than in former days, and has created a demand for the higher and more expensive grades of movement, and rendered nearly useless all cheap pocket time-keepers. But it is evident that the markets of watch-demanding countries are not to be quietly possessed by these American manufacturers. Already organizations are on foot abroad both as to the production of watch-cases and watch-movements, upon the American idea and under American superintendence, so that competition—that inspiring force in human activities—is still to be an important factor in this interesting department of mechanical industry.

As a matter of information, it may be opportune to remark here, that gold articles of jewellers' work, both of ornament and utility, and many other

productions of varied character related in some way to such mechanical artisanship, manufactured in the United States, have long found European and other foreign orders, and to these may, of late, be added silver and silver-plated wares, and gold and silver watches in constantly increasing volume.

It is manifest that under the stimulating wealth of suggestion and educational influences of the International Exhibition at Philadelphia, new ideas and fresh enterprises are springing into the industries of the United States. The workshops and products of their artisans in various directions are already foreshadowing this, and it is desired that these advantages may in some measure be reciprocally enjoyed by the enterprising visitors of other lands who honoured the Exhibition with their presence.

American agencies in European cities for the introduction of American manufactures are being established, which, but for the intelligence and experience elicited by the Centennial Exhibition, might have waited years longer for such demonstration.

GENERAL REPORT

ON

GROUP XII.

LEATHER AND MANUFACTURES OF LEATHER.

JUDGES.

F. H. PIERPOINT, Fairmount, Marion County, W. Va.

JOHN CUMMINGS, Boston, Mass.

THOMAS MILES, Philadelphia, Pa.

J. PARKE POSTLES, Wilmington, Del.

M. GUIET was temporarily assigned from Group XVII. to assist in the examination of leather.

GENERAL REPORT.

LEATHER AND MANUFACTURES OF LEATHER.

The Judges of Group XII., after completing their examination, can but express their pleasure at the extensive and varied exhibition, embracing every variety from an infant's shoe to a man's cavalry boot.

Great Britain and Colonies.

The exhibit of boots and shoes in the English department was small, but of a very superior quality consisting of hand-stitched men's and women's work, of all the finer styles of boots, gaiters, and high and low shoes. The boot-legs and uppers were very superior; the stitching was elaborate; the work sewed by the American McKay sole-sewing machine was of a very heavy and substantial character; and the workmanship and finish were excellent. They also exhibited a lock-stitch wax-thread sole-sewing machine (we should say an improvement on the McKay, using its horn) displaying considerable skill. It is a very heavy and well-built machine, and the work sewed on it was of a strong, heavy, and durable quality.

Canada.

An extensive exhibit of men's, women's, misses', and children's boots, gaiters, high and low shoes, hand-stitched, McKay machine-sewed, heavy-pegged work, &c. Some of the hand-stitched work was very fine, of superior finish, and compared favourably with the best work exhibited.

The McKay machine-sewed and heavy-peg work was of a strong, substantial character, full in width, and suitable for home trade, but in finish and workmanship it does not compare with that of some other countries. The only piece of shoe-machinery on exhibition was a peg-break. As it was not put in operation we could not judge of its merits.

Victoria.

An exhibit of men's and women's fine hand-stitched boots, gaiters, and shoes, very excellent in material and workmanship. For style, finish, and proportions they compared favourably with any exhibited.

France.

The exhibit of boots and shoes was quite extensive, principally of the finer grades of work for men. All the styles and patterns of fine hand-stitched and pump work were represented.

Of women's goods there was a very elaborate display of silk, satin, embroidered and painted, with lace and a variety of trimmings, intended for stage and party purposes, &c., also some kid and plain work. It was a handsome display.

Germany.

The exhibit of boots and shoes was very small. From Mayence came a very superior exhibit of hand-stitched men's gaiters, high and low shoes, and McKay (American) machine-sewed shoes, which were of good material and firm, solid work; but the finish was not fine. Some military and hunting boots were exhibited as novelties.

Austria.

There were only three exhibits of boots and shoes, a very small representation of that branch of industry. From Vienna was an exhibit of hand-sewed men's and women's toilet slippers, tastefully and neatly trimmed; a fair article.

Russia.

The exhibit of boots and shoes was small, comprising men's hand-sewed riding, hunting, and dress boots and shoes, with fine peg-work; also fishermen's heavy boots, galoches, &c.; also women's satin, silk, and kid gaiters, slippers, &c.; stage and fancy shoes in a variety of styles, displaying taste and excellence of workmanship; with some cheap grades of work. There was a very extensive exhibit of calf-skins fair (unblacked), boot and gaiter fronts, crimped and uncrimped; also horse-hide uncut skins. The calf-skins were of very superior tannage, very fine texture, and beautiful grain. Horse-hide leather was shown very fine, soft, and mellow; also colt skins, finished and dyed for gloves, which were very fine.

Italy.

An extensive exhibit of men's and women's boots and shoes, &c. Hand-stitched work in a large variety for men's riding, hunting, and plain boots, gaiters, high and low shoes, &c. Women's silk, satin, and kid button and lace gaiters of generally good material and workmanship. Also an exhibit of lasts and forms for shoemakers, boot and shoe trees, stretchers, &c., the designs and proportions of which were very good.

Spain.

A large exhibit, consisting of men's hand-stitched work, in a variety of patterns and styles; women's pump or thin-sole work, of satin, silk, and kid; and gaiters, slippers, &c., with styles to suit the Andalusian ladies, the workmanship and material of which were generally excellent. There was also an extensive exhibit of list and woven uppers and hemp sole shoes, intended for army and peasant use, at extremely low prices.

The women's riding bridles and saddles from Madrid constituted a very superior exhibition of taste, skill, and substantial workmanship. The Andalusian bridles and saddlery from Malaga were a very superior exhibit of this class of work, with elaborate ornamentation in embroidering, &c., to suit the taste of Andalusia.

Portugal.

An extensive exhibit of men's, women's, and children's boots, shoes, and gaiters, hand-stitched and pump boots, shoes, and gaiters, of a variety of patterns and styles; and satin, silk, and kid button and lace gaiters, got up for party and dress occasions, of very fine material and excellent workmanship. There was, moreover, a large exhibit of wood-sole shoes with patent-leather uppers, very handsomely stitched; also some plain goods with beaded list, and carpet shoes at low prices.

Luxemburg.

A small but good exhibit of boots and shoes; men's hand-stitched and screwed, high shoes, army brogans, screwed; and heavy mining shoes, hob-nailed, of prime material and very substantial; also fine hand-made gaiters, &c., for men and women.

Norway.

The exhibit of boots and shoes was small, but generally of very excellent quality, including men's and women's hand-sewed boots, gaiters, shoes, &c., of superior workmanship and material, with some peg and cheaper grades of work.

Sweden.

The exhibit of boots and shoes was very excellent, consisting principally of hand-stitched men's boots, gaiters, &c.; riding, walking, cork-soled, patent-leather, tongue boots, of superior workmanship and material; also some superior peg-work, and a small exhibit of women's satin, French kid gaiters, &c.

Belgium.

The exhibit of boots and shoes was extensive, and embraced some very superior hand-sewed work for men and women; also screw and cheap grades of work.

China.

An illustrated exhibit of the Imperial Government, consisting of the shoes peculiar to the country, deposited by the Imperial Maritime Customs of Shanghai, Amoy, Canton, Chefoe, Minchang, and Chinking. These were instructive and interesting, as illustrating the tastes and customs of the people in this respect in the different parts of the Empire.

Brazil.

A very extensive exhibit of shoes; McKay machine-sewed, French screw-machine, and hand-sewed shoes, from the House of Correction, &c., of excellent material, and good, fair, substantial workmanship, with lasts or forms for men's, women's, and children's goods; also a collective exhibit from Rio de Janeiro and different provinces of the Empire, consisting of hides, skins, leather, saddles, &c.; an instructive exhibit, illustrating the different animals of Brazil, and the condition of the leather industry, &c., in the different parts of the Empire.

Argentine Republic.

The exhibit of boots and shoes was quite extensive, comprising hand-stitched riding boots and gaiters of good workmanship, with excellent taste, style, and material; together with cheaper grades of work, made very substantially; also a large collective exhibit, made by the Government, representing the different provinces of the Republic, consisting of boots, leather, dry-salted and dry-flint hides, goat and sheep skins, and skins of different animals of the country.

The exhibit was intended to illustrate the resources of the country in hides and skins for export or home consumption, and the progress of the leather and shoe industry of the country.

Chili.

A fair exhibit of fine hand-sewed men's enamelled leather riding boots, fancy congress gaiters, women's satin gaiters, &c., of excellent workmanship and good material, taste, and style.

Venezuela.

A very handsome exhibit of men's, boy's, and women's fine hand-sewed and fine copper-nail, bevel-edge boots and gaiters, cloth-embroidered slippers, and women's and misses' gaiters and slippers, of very superior workmanship and material, and excellent taste and style.

United States.

A very extensive exhibit of men's, women's, boys', youths', misses', children's, and infants' kid, goat, serge, silk, satin, &c., of finest hand-made and machine-sewed work, in every conceivable design, with heavy kip, grain, and wax upper leather boots, brogans, &c., made pegged, sewed, screwed, and nailed, suitable for the farmer, miner, and labouring classes, with a great variety of lower grades, at very reasonable prices, to supply the masses. The shoe-machinery and wax-sewing machines were deserving of especial mention, as a very extensive exhibit adapted to the manufacture of the shoe. There were dies and press for uppers and soles; wax-thread-sewing machines for fitting leather uppers; the silk and thread sewing machines for fine-class work, with elaborate, fancy, and embroidered stitching, not surpassed by any country in the world; the McKay sole-sewing machine, used in most foreign countries, as well as all through the United States, and the Goodyear welt and turn sewing machine, also the Cutlan turn-sewing machine and others, with a variety of screw, nail, and pegging machines; the McKay lasting-machine, for placing the upper over last, with tacker to fasten the upper to the insole, after

adding outsoles ready for sewing; sole-moulding machine, for moulding the sole to the bottom of the lasts; edge-turner, edge-setter, heeling-machines, heel-burnishers, sand-paper machines, sole-stripping machines, rollers, skiving and splitting machines, and revolving and beam sole-die machines, with a variety of other machines we have not space to enumerate. These machines are mostly adapted to both foot and steam power; they displayed considerable skill and ingenuity in construction, and the work was done in a very efficient, rapid, and masterly manner. While we are not willing to accord to all the machines the great economy claimed by exhibitors over hand-labour, we are satisfied that use of many of the machines will save labour, and that they will do their work in an efficient and workmanlike manner. There was also an extensive exhibit of shoe-rasps, files, knives, and tools of great variety for the fitter and sole-finisher, very skilfully made; also eyelet-setters, button-fasteners, patterns of zinc and paper for the uppers and soles of shoes, artistically designed and correctly graded; shoe-rivets and machines for setting the same; lasts or forms, boot and shoe trees, stretchers, in large variety and designs; boot and shoe crimping machines, doing the work very rapidly and efficiently, and a variety of machines and tools for the manufacturer not enumerated.

When we take into consideration the extensive exhibits displayed in the Shoe and Leather Building, where not over ten per cent. of the tanners and manufacturers were represented, we congratulate the Commission on the increase and development of that branch of our industry.

Report on Leather, and Machinery used in its Manufacture.

Nearly every nation in the world was represented in the leather department, and the exhibits were most interesting and instructive. The various kinds and qualities of leather adapted to the wants of peoples separated from each other by climate and race, influenced in their designs and tastes by the most widely-different customs and habits, were nearly all brought under one roof, and could be easily compared.

A notable feature of this exhibition of the leather products of the world was the rare opportunity it afforded to measure the improvement which modern science has effected in the art of tanning, and this improvement was to be remarked in the manufactures of some of the new colonies, as well as in those of the older countries. This exhibition of the leather of the world will stand alone among Exhibitions for its completeness, variety, and excellence, and as a point from which to mark and note the improvements in inventions of the future.

Great Britain.

This exhibit of leather was lamentably small. There was but one exhibit of sole leather; and, while this showed a good degree of skill in the preparation of the hide, it also showed an imperfect tannage. Morocco, in fancy colours, for bookbinding, satchels, pocket-books, upholstery, and fancy leather-work, also Russia leather, and sheep-skins and skivers, in a great variety of colours and finish, evinced the highest skill, especially in the colouring and finishing, and took rank with the best goods of this class in the Exhibition.

New South Wales.

This exhibit, while not as large and varied as those of some of the older nations, was very creditable to so new a country. The sole leather gave evidence that this department of industry was in the hands of men of skill and enterprise. A notable part of the exhibit was leather made from kangaroo-skins, and the patent and enamelled leather made from these skins was remarkable for fineness and toughness of grain.

Australia.

A small variety of leather was exhibited. It was very noticeable for high skill and workmanship and in the perfection of the manufacture. It is apparent from this limited exhibit that this country has the means of producing leather of a high standard, and that its people are able to make this industry most valuable.

Canada.

The exhibit of leather, entirely of hemlock tannage, was not very extensive. It showed skill and good workmanship. It comprised upper, sole, and harness leather.

France.

A large and varied assortment of leather of all kinds was exhibited. The sole leather, tanned with oak-bark, showed high skill in the preparation of the hide, causing a minimum loss of hide material in the process; it was of superior quality, and indicated the highest integrity in the manufacture. The calf-skins were none of them fully up to the high standard of French skins. The morocco, comprising black and fancy colours, black glacé, and fancy-coloured kid, fully sustained the high reputation which it has long maintained. It was noticeable for its elasticity, pliability, and toughness, and for the delicacy of shades, depth, bloom, and permanence of colour.

The glacé kid is worthy of special mention for its mellowness, toughness, and its exceedingly beautiful and permanent gloss. The skins are usually tanned open, with Sicilian sumac.

Germany.

A small amount of sole leather, finished and unfinished, which did not indicate any noticeable degree of skill in its manufacture, was exhibited. The morocco, kid, &c., of black and fancy colours for shoes, colours for bookbinding and fancy leather-work, glacé kid, and white and coloured kid-skins for gloves, &c., evinced high skill and integrity and the most careful and intelligent attention to the details and processes of manufacture, especially in the preparatory processes and tanning, and the colouring and finishing of fancy colours for bookbinding and fancy leather-work. The exhibit of kid-skins for gloves was remarkable for fineness of texture, elasticity, etc.

Austria.

This exhibit was quite extensive in variety of production, and evinced a good degree of skill and workmanship. Many kinds of upper leather were highly creditable to the producers.

The black and fancy-coloured moroccos and white kid-skins, for shoes and fancy leather-work, showed high skill in the manufacture. The fancy colours were noticeable for the beauty and delicacy of colouring and excellence of finish which have long made Vienna's fancy leather goods famous. The sole leather, while it was well prepared, was faulty in not being thoroughly tanned.

Sweden.

A small amount of various kinds of leather was exhibited. The upper leather was not equal to the standard of modern workmanship, and the sole leather showed only fair skill in the preparation of the hides, and was deficien in tannage.

Norway.

Sole, upper, and harness leather, of oak tannage, was exhibited. The sole leather showed good skill and workmanship in its production, while the upper leather, though fairly made, indicated the use of inferior materials in the finish.

Italy.

A limited variety of leather was exhibited. There was sole leather, notable for its evidence of high skill and workmanship in the manufacture throughout, but most of the exhibit showed that the modern means and improvements had not been used in this industry.

Brazil.

This exhibit of leather made from the skins of a great variety of animals was notably lacking in the application of modern skill and workmanship.

Argentine Republic.

An extensive variety of upper, sole, and harness leather was exhibited, of which but a small part had been manufactured by the later methods now in

use in other countries; and it was evident that the leather would be greatly benefited by the introduction of modern skill and workmanship.

The manner in which the leather was exhibited was such as to place it at a further disadvantage.

Spain.

This exhibit comprised quite an extensive variety of leather, but, with few exceptions, it did not show any high degree of skill in its production.

Portugal.

A variety of calf, kip, and sole leather was exhibited. A portion of the calf-skins were of very fine quality, while the rest were lacking in modern skill and workmanship. Some of the sole leather was notable for high skill in the preparation of the hide and its manufacture; the rest lacked complete tannage and was deficient in skill in the production.

Turkey.

A variety of leather of various kinds and styles was shown. The entire exhibit, owing to its exposed condition, had been very much injured in appearance, and consequently was placed at a great disadvantage. The morocco and sheep leather appeared to be thoroughly tanned, and some of the colours, especially the reds, blues, and yellows, were very clean, strong, and beautiful. The leather showed, however, that this country did not use the modern processes and appliances in its manufacture, but still adhered to its old traditions and the processes of former times.

Russia.

This exhibit comprised an extensive variety of all kinds of leather, in a great variety of styles, for which this country has for a long time been noted. The sole leather showed good skill in the preparation of the hide, but it generally was deficient in tannage. The principal tanning materials used are willow-bark and kermes. The upper leather, made from calf-, kip-, and cow-hides, was shown in various methods of preparation, and generally evinced high skill and workmanship. The carriage leather was also quite superior in its manufacture. The exhibit of light leather consisted of grain-calf for shoes, finished in imitation of morocco, and notable for its solidity and toughness of grain; and of the famous Russia leather in black and fancy colours,—heavy for boots, trunks, portmanteaus, &c., and light for fine fancy-work; and colt-skin glove leather, which was remarkable for fineness of grain, texture, elasticity, and toughness, as well as for beauty and evenness of colours. The whole exhibit was marked by very high skill in its manufacture.

Venezuela.

A very limited exhibit, showing only a fair amount of skill. The sole leather was not completely tanned.

United States.

This country exhibited all kinds and varieties of leather. The larger part of these exhibits was from the States of New York and Pennsylvania. Maryland, Ohio, and Kentucky were only fairly represented in the sole-leather department. The New England States were not so well represented as the magnitude of this industry would have warranted. Of hemlock sole leather the quality of the production of this country was well represented, and it was plainly to be seen that a high degree of intelligence had been employed in the manufacture of these exhibits.

The improved methods of preparing the hides make it evident that under the modern processes there is much less loss of hide-material, much less time consumed, and much less waste of gelatine and gluten than under the old methods, thereby producing a more compact and durable leather. The exhibits of oak and hemlock sole leather showed that the tanners are no longer following the old practices of the past, but are bringing to their aid the improvements which modern science has demonstrated to be good and useful. Much of the oak-tanned sole leather was notable for high skill and workmanship.

The leather from Ohio and Kentucky was of a high order of excellence, thorough tannage being a marked feature in this department.

With the exception of calf-skins the exhibit of upper leather was not so full as was desirable or might have been expected; and, with a few exceptions, this leather did not indicate any high degree of skill or workmanship, and was not a fair standard of the quality of the product of the country. There was a large exhibit of calf-skins, and several of them showed a thorough knowledge of the art of manufacture, and were fully equal to any on exhibition. The extensive exhibit of harness leather, mostly of oak tannage, was marked by a good degree of skill and excellence, and was very creditable to the manufacturers. It is apparent that, however much difference of opinion may exist as to the comparative merits of oak or hemlock tanned sole and upper leather, there can be no doubt that the oak tannage must claim and secure the preference for superior harness leather.

The exhibit of morocco and light leather was not large, but was measureably complete in its representations of the different varieties manufactured in this country. The growth of this branch of the leather industry has been very marked during the last twenty years, both in the amount produced and the skill and excellence of manufacture, which is most apparent in the production of fancy-coloured morocco and sheep leather for shoes, bookbinding, satchels, fancy leather-work, &c. This was illustrated by several complete and very beautiful exhibits of this class of goods, of delicate shades and colours, of all the different styles of finish, that rival and compete with even those countries which have long held pre-eminence in these departments of industry. These remarks hold equally true of different varieties of black morocco, kid, &c., of which there were specimens of very superior merit.

The most noticeable point of merit shown in American morocco, &c., is the great care taken in the finishing processes, and the excellence attained in this respect. There is evidently more care bestowed upon the final or finishing processes than upon the earlier processes of preparing and tanning the skins; from which fact American morocco is noticeable for fineness and solidity of grain, depth and fullness of colour and clearness of gloss. It is mostly tanned with American and Sicilian sumac separately, or a mixture of both, and usually by sewing the skin in the shape of a bag and filling it with the tan liquor, which is pressed rapidly through the pores of the skin, thereby effecting the tanning much quicker than when the skins are suspended in the liquor, allowing the tannin, the fibrin, and the gelatine to combine by natural operation or affinity. Machines for sewing these skins are now in almost universal use in this country.

There was exhibited but little machinery adapted to the manufacture of leather, and while the machines on exhibition showed a good degree of skill in construction and intelligence for the purposes required, they were so deficient as labour-saving machines that they could not be commended for general use.

In the Government Building there was a collection of leather made from animals representing all the orders of the animal kingdom, from the reptile up to man, the notable feature of the exhibit being its variety. No high skill was indicated in the manufacture. The leather from some of the animals was very well made, but other specimens were below the ordinary standard. That made from the skin of the white whale was a novelty that suggests a new resource for the tanner.

Report of Expert on Leather Tests.

No. 149, Broadway, New York, October 1876.

Messrs. Cummings, Miles, Postles, and Pierrepoint, *Judges in Group XII., U.S. Centennial Exhibition:*

I submit the following report of experiments made, under your direction, to determine some of the qualities which affect the value of different kinds of leather when used for the soles of shoes. These experiments were made at the Centennial Exhibition, during this year, on the various samples of sole-leather exhibited there.

Selection of Samples.—The Judges of leather, appointed by the Centennial Commission, selected sixty-six sides, from all those exposed to be experimented on. A sample was cut from each of these sides, from that part

which came nearly over the kidneys. These samples were marked with the exhibitor's number and given to me.

Relative Dryness of the Leather.—These sides had all been hanging in the Exhibition buildings since the opening day (May 10, 1876), and therefore had been in a dry room during the two months preceding these experiments. All of the oak, union, hemlock, Russian, and South American leathers were hanging in the Shoe and Leather Building. The others came from the Agricultural Hall or the Main Building.

After being cut, the samples were kept, for some days, in a drawer in a desk in the office. Although it would appear that all had had an opportunity, extending over two months, to become equally dry, it is not certain that they were so. The only reason I can assign, that can practically have had any effect, is, that the floors of the building were kept continually wet by sprinkling, to keep down the dust. It is possible that those sides which hung nearest to the passage-ways were affected more by the moisture arising from the floor than those which hung farther away. The effect of this must, however, have been neutralised during the two weeks the samples were kept in the table-drawer before being weighed.

General Plan of Experiments.—1st. Each sample of leather was cut from the side with the same die.

2d. The samples were all weighed.

3d. The thickness was measured.

4th. They were all thoroughly dried, at a temperature of 160°.

5th. They were all weighed, as in the dry state.

6th. They were all thoroughly washed and scoured, in cold water.

7th. They were all weighed when thoroughly saturated with water.

8th. They were all compressed by a force of two thousand pounds per square inch.

9th. They were all dried at a temperature of 160°.

10th. They were all weighed in the dry state.

11th. They were experimented on to determine rapidity of absorption of water, as explained hereafter.

12th. They were placed on grinding-machines and ground for two hours, seven pieces being ground at the same time.

13th. They were dried again at a temperature of 160°.

14th. They were all weighed in the dry state, the difference between this weight and that given at the tenth step being the loss by grinding for two hours.

Size of Samples.—The samples were all cut with the same solid steel die, which was a square, $3\frac{1}{2}$ inches (8·89 centimetres), and therefore had an area of $12\frac{1}{4}$ superficial inches (7·90 centimetres).

Measurement of Thickness.—This was done with a pair of calipers divided to $\frac{1}{100}$ inch (0·0254 millimetre). Each sample was measured in four places, and the mean of the four taken as the thickness. In the table appended to this report the thickness of each sample is given. The following is the mean of all samples from the same country, or the same kind of tannage.

Table I.

Mean thickness of all samples of leather of the same tannage in the condition in which it was exhibited, both as to dryness and hardness of rolling, and of leather.

	Thickness.	
English	0·290 inches.	7·366 millimetres.
Oak (American)	0·269 „	6·847 „
Australian	0·259 „	6·589 „
Hemlock	0·244 „	6·198 „
Union	0·242 „	6·147 „
Austrian	0·242 „	6·147 „
South American	0·225 „	5·720 „
Italian	0·216 „	5·486 „
Swedish and Norwegian	0·214 „	5·436 „
Russian	0·210 „	5·334 „
French	0·210 „	5·334 „
German	0·208 „	5·283 „

Weight of Samples.—All the samples were next weighed on a very sensitive balance, having a capacity of $\frac{5}{8}$ of a pound (0·366 kilo.), and sensitive to one grain (1·6 centigramme). The pieces were all weighed on the same day, the whole process lasting a little more than an hour. The variation in weight of any piece, from the absorption or evaporation of moisture during this hour, must have been insensibly small. The average results of this weighing are given in Table II.

Table II.

Mean weight of samples (3½ inches)=88·9 centimetres (square) in the condition in which they were exhibited.

English	54·23 grammes.	German	42·29 grammes.
Oak (American)	51·22 „	Swedish and Norwegian	41·37 „
Hemlock	50·89 „	Italian	39·10 „
French	49·41 „	South American	37·95 „
Australian	49·06 „	Russian	36·48 „
Austrian	48·24 „		
Union	46·65 „		

These are the actual weights and thicknesses in the condition exhibited. How much of the variations are due to the original hide, and how much to the hardness of rolling, or other variations in methods and materials used in tanning, does not appear. In order to compare the actual weights of the leather the following table has been prepared, which gives the weight of a square foot, ¼ inch thick, and is computed for each leather, as shown in detail below for hemlock:

Weight of sample, 3½ inches square	50·89 grammes.
„ „ 1 square inch, $\frac{50\cdot89}{12\cdot25}$	4·163 „
„ „ 144 square inches, 4·163×144	599·472 „
„ „ „ „ $\frac{1}{100}$ inch thick, 599·472	24·57 „
„ „ „ „ $\frac{25}{100}$ „ „ 24·57×25	601·4 „

„ „ 1 square foot, ¼ inch thick=601·4 grammes=1·343 pounds.

It must be remembered that these figures only apply to the leather on exhibition. It seems to be generally acknowledged among leather-dealers that the oak leather on exhibition was heavier (*i.e.*, thicker) than the average offered in the market, while the hemlock and the union were about the average. The inference, then, would be that the hemlock leather in the market is *more* than 12½ per cent. heavier than the oak, for a square foot of equal thickness.

Table III.

Calculated mean weight of a square foot of leather of various tannages, if ¼ inch thick.

French	1·52 pounds.	Oak (American)	1·23 pounds.
Hemlock	1·37 „	Australian	1·23 „
German	1·31 „	English	1·20 „
Austrian	1·29 „	Italian	1·17 „
Swedish and Norwegian	1·25 „	Russian	1·12 „
Union	1·23 „	South American	1·09 „

There was only one sample of English leather, while there were several samples of every other kind. A fair comparison cannot be based on one sample, and therefore the English leather must be omitted in considering the foregoing. Omitting the English, it appears that the oak is at the same time the thickest and the heaviest leather on exhibition (Tables I. and II.). The relative weights of the three American leathers are:

Oak 100·0	Hemlock 99·3	Union 90·1

And the relative thicknesses are:

Oak 100·0	Hemlock 90·7	Union 90·1

From these figures it appears that the actual weights of the oak and hemlock leathers are nearly equal, while the hemlock is nearly ten per cent. thinner;

and, on the other hand, that the union is about ten per cent. lighter and also ten per cent. thinner than the oak. It would appear that there must be some essential difference in the method of treatment of these leathers, that makes the oak and the union leathers thicker than the hemlock, for the same weight. Whether this difference is due to the pressure used in rolling, to some variation in the treatment during the processes of removing the hair and flesh, trimming, finishing, &c., or to some chemical effect of the oak or hemlock bark, does not appear; but as the oak leather, which is made entirely from oak-bark, and the union leather, which is made from $\frac{7}{8}$ hemlock and $\frac{1}{8}$ oak, are nearly the same, while the hemlock leather is ten per cent. heavier, it would not appear that the variation could be due to the substitution of $\frac{1}{8}$ hemlock-bark in place of the oak, and therefore not to the difference in the chemical effect of the bark.

After having been measured and weighed, as described above, the leather was carefully and thoroughly dried and weighed again, to determine how much water had been dried out. The drying was done by exposing the leather to a current of air, heated by a gas-burner to a temperature of 160° F. (71·1° C.) The temperature was regulated as carefully as possible, and never rose beyond 165° F. (73·3° C.) or fell below 155 F. (68·9° C.) The time required to thoroughly dry the leather was about twenty-four consecutive hours, but the actual time was longer than that, as the leather absorbed during the night, towards the end of the drying process, almost as much as was dried out during the day. The results of the drying are given in Table V.

TABLE V.

Mean weight of samples of leather of various tannages (3½ inches square), when dried at 160° F. (71·1° C.)

English	49·36 grammes.	German	37·79 grammes.
Oak (American)	46·74 „	Swedish and Norwegian	36·94 „
Hemlock	46·10 „	Russian	36·79 „
French	44·38 „	Italian	34·88 „
Austrian	43·93 „	South American	34·05 „
Australian	42·94 „		
Union	42·05 „		

From this table the percentage of actual weight lost by drying at 160° may be computed.

TABLE VI.

Mean loss of weight, by drying at 160° F., by leather of various tannages, the original weight of the leather, in the condition it was exhibited, being 100.

Italian	10·7 per cent.	South American	10·2 per cent.
*Australian	12·4 „	Russian	10·0 „
English	10·8 „	Union	9·9 „
*Swedish and Norwegian	10·7 „	Hemlock	9·4 „
*German	10·6 „	*Austrian	8·9 „
*French	10·2 „	Oak (American)	8·8 „

The following table represents the variation in weight of a second set of samples from all the sides of oak, hemlock, and union leather mentioned in this report. The samples were each 2¾ inches (5·27 centimetres) long by 1½ inches (3·81 centimetres) broad, and were cut as nearly as possible from the same place as the original samples. They were weighed every day, being allowed to lie during the interim on a window-sill, where they were exposed to a current of air, but protected from the sun and rain. The weighing was commenced after a season of hot, dry weather, and continued through a season of rainy weather into warm, dry weather again. All of the oak were weighed at once, as were all the hemlock and all the union, so the variations only show the mean for each kind of leather. The thickness of the samples was the same as given in Table I.

It will be seen that the specimens became from $2\frac{1}{10}$ to $2\frac{2}{10}$ per cent. heavier in the rainy than in the clear weather, the hemlock varying the most, as in the

* These pieces came from Agricultural Hall or the Main Building.

case of drying at 160° F., Table VI., and the oak the least. The difference between the variations of the oak and hemlock are in about the same proportion as indicated in Table VI. Thus, hemlock loses by drying at 160° 9·4 and oak 8·8 per cent., the hemlock being more than the oak in the proportion of 107 to 100. The hemlock gains, by exposure to damp air, $2\frac{2}{10}$, while the oak gains $2\frac{1}{10}$ per cent., the hemlock being more than the oak in the proportion of 105 to 100, or nearly the same as before.

Table VII.

Showing the variation in weight of eleven pieces of oak, eight pieces of hemlock, and ten pieces of union leather, from the variation in the temperature, or in the hygrometric condition of the atmosphere.

Date.	Weights.						Thermometer. F.	
	Absolute. Grammes.			Relative.			Wet.	Dry.
September.	Oak.	Hemlock.	Union.	Oak.	Hemlock.	Union.	Deg.	Deg.
*6.—A.M. -	191·40	134·93	150·47	100·0	100·0	100·0	67	77
†7.—A.M. -	191·95	135·40	150·88	100·3	100·3	100·3	67	70
†8.—A.M. -	194·88	137·35	153·48	101·8	101·8	102·0	66	67
†8.—P.M. -	195·41	137·90	153·95	102·1	102·2	102·3	67½	70
‡9.—A.M. -	194·45	137·22	152·95	101·5	101·7	101·7	69	70½
‡11.—A.M. -	193·60	136·70	152·40	101·1	101·3	101·3	62	65
‡11.—P.M. -	193·85	136·90	152·55	101·3	101·5	101·4	62	65
‡12.—A.M. -	193·60	136·55	152·20	101·1	101·2	101·1	63	68
*13.—A.M. -	193·75	136·85	152·60	101·2	101·5	101·4	65	69
*14.—A.M. -	194·10	137·00	152·75	101·4	101·6	101·6	67	71

After being exposed to the atmosphere till September 14, the pieces were placed in a warm-water bath, and the weight, after they had been exposed to the temperature given in the table so long as not to lose any more weight, determined. The warm-water bath consisted of a tin box, with hollow walls and bottom, which were filled with water. The top had a tin lid, which, during the experiment, was closed and covered with a piece of felt. The water in the walls was heated by a lamp until the thermometer, inserted in it, showed the temperature marked in Table VIII. The bath was 6″ by 4″ by 5″ inside.

Table VIII.

Mean weight of the same pieces of leather as in Table VII., when dried in the water-bath, at various temperatures.

Temperature.	Weights.					
	Absolute.			Relative.		
	Oak.	Union.	Hemlock.	Oak.	Union.	Hemlock.
Atmospheric.	191·40	150·47	134·93	100·0	100·0	100·0
100° F.	180·60	142·20	127·60	94·3	94·6	94·6
120° F.	176 90	138·40	123·80	92·4	92·0	91·8
140° F.	173·90	135·90	122·15	90·8	90·2	90·5
160° F.	171·65	134·50	120·45	89·6	89·4	89·7
Atmospheric.	190·75	149·85	134·55	99·6	99·7	99·8

* Clear. † Rainy. ‡ Cloudy.

It will be noticed there is a considerable difference in the weight lost by the various kinds of leather, the Italian losing the most and the American oak the least. There is also considerable variation in the amount lost by different specimens of the same tannage, and every specimen lost some water when warmed to a temperature of 160°.

It has been found by experiment that every kind of wood always contains a certain amount of water, varying, within small limits, with the hygrometric condition of the atmosphere, but which will not permanently decrease, even after many years. This amount of water varies with different kinds of woods. It is stated by various authorities that air-dried wood, stored for some time under sheds, will contain from fourteen to sixteen per cent. of water, as compared with the same dried at 150° F.; and that, on being re-exposed to the atmosphere, it will re-absorb this fourteen to sixteen per cent. of water from the moisture in the air. Certain materials which enter into the composition of leather in larger or smaller quantities, particularly salt and lime, have the property of absorbing a considerably larger proportion of moisture than fourteen to sixteen per cent. It may be that the variations in the proportion of moisture lost by the different samples is due to the varying proportion of these bodies.

All leather will gain or lose in weight from the variations of the amount of moisture contained in the atmosphere. A piece of leather may properly be said to be *dry* when it will not gain or lose any weight from continued exposure to the same atmosphere. If, however, this leather be first weighed after hanging a week or more in a dry loft during the summer season, when the mercury ranges from 90° to 100° F.; and then, again, after a few days' rain, when the mercury has fallen from 60° or 70° F., and all the air is charged with fog or mist (even though no rain or water of any kind shall have entered the loft), it will be found to have increased in weight from 1½ to 2½ per cent.

If the same leather is laid out in the sun to dry it will, after a few hours, be found to have fallen short of its original weight from six to eight per cent. The limits of variation of weight of leather under practical circumstances are probably as follows:

Weight of leather in dry weather	100·0
„ „ wet „	101·5–102·5
„ „ dried in the sun	92 – 94

After being warmed to 160°, the leather was taken out of the bath and allowed to re-absorb, from the atmosphere, as much moisture as it would, in order to see if anything but water had been driven off. It appears that the leather did not become as heavy again, after being heated to 160° F., as before, the loss, however, being only $\frac{1}{10}$ per cent. in the worst case. This loss was probably some very volatile essential oils, which were vaporised at or below that temperature, and were sensible by the very delicate odour that arose from the leather during the first part of the drying. The loss in drying at 160° F., by this experiment, was:

Oak - 9·2 per cent. | Hemlock - 9·5 per cent. | Union - 9·8 per cent.

while the loss from drying, at the same temperature, in the experiment given in Table VI., was:

Oak - 8·8 per cent. | Hemlock - 9·4 per cent. | Union - 9·9 per cent.

The union and the hemlock are almost the same, and the variations in the oak are less than one-half of one per cent.

After the specimens were thoroughly dried, as shown by Table VI., they were all thoroughly washed in water having a temperature of 85°, to learn how much could be washed out. To effect this, they were placed in an iron tank, holding about a barrel of water, the water being continually circulated by a centrifugal pump. The pieces were soaked in this tub for ninety-six hours, during which time the pump was running twenty-eight hours. On being taken out of the tub, they were each carefully examined, to see if any soluble matter remained, which was done by rinsing them in clean water, the soluble matter, if there were any, coming out and soiling the water. When any of the pieces did not appear to be washed clean, they were rubbed until they did appear to be so. It was noticed that the matter washed out of the hemlock leather was a deep red, and that from the oak a yellow-white. Having been washed clean, the samples were allowed to lie in a tub of clean water a few minutes, and then weighed while wet; as in that condition the leather had taken up as much

water as it could hold. This weighing was done by taking the piece from the water and laying it in a wire basket, hung from the scale-beam, and carefully counterbalanced. The sample was not wiped off or dried, and the weight given in the Appendix and in Table IX. includes the little water that adhered to the leather, as well as that contained in the pores. The water adhering to the surface was found to be less than one-half gramme, or about two-thirds of one per cent. In this condition the leather undoubtedly absorbed more water than before the soluble matter was washed out, as the pores originally occupied by the soluble matter were now empty and ready to be filled with water.

TABLE IX.

Mean weight of samples of various tannages, when thoroughly saturated with water, after having been previously dried at 160° *F., and all soluble matter washed out in cold water.*

English	80·80 grammes.	Russian	63·88 grammes.
Oak (American)	76·82 „	South American	64·64 „
Australian	74·66 „	German	61·22 „
Hemlock	74·44 „	Swedish and Norwegian	60·69 „
Austrian	71·50 „	Italian	61·29 „
Union	69·84 „		
French	66·18 „		

The relative weight of the samples, before being washed or dried, and when washed and thoroughly soaked, being the proportion of water absorbed, is given in Table X. There is considerable difference in the proportion of water absorbed, the soft and spongy leathers generally taking up the most. The Russian and South American, which took up the most, absorbing from seventy to seventy-five per cent., were soft and pliable both when wet and when dry, while the French, which took up the least, was hard and stiff both when dry and when soaked. The oak, which was generally hard when dry, usually became soft when wet, while the hemlock was hard both when wet and dry.

TABLE X.

Mean relative weights of samples, when thoroughly soaked, and when in original condition, the weight in the original condition being 100.

Russian	175·1	English	148·9
South American	170·3	Union	148·0
Austrian	154·8	Swedish and Norwegian	146·7
Italian	154·2	Hemlock	146·3
Australian	152·5	German	144·8
Oak (American)	149·9	French	133·8

After the pieces had been weighed in air they were weighed in water; that is, the wire basket in which they were placed to be weighed was suspended from the balance so it came beneath the surface of the water in a tub below. In this arrangement, whatever portion of the weight of the leather was floated by the water, is relieved from the weight borne by the balance; the weight required in the other scale-pan to counterpoise the leather, thus partly floated by the water, represents the difference between the weight of the leather and the weight of an equal volume of water. The pores and cells in the leather being all filled with water, the difference is really the difference between the actual weight of the fibres and the weight of an equal volume of water. By afterwards taking the leather from the water and drying it, we may learn the actual weight of the fibres. This weight is given in Table XI. The weights of various samples in water are given in the Appendix.

TABLE XI.

Mean weight of samples of various tannages, after all soluble matter is washed out, and the residue dried at 160° *F.*

Hemlock	43·15	French	39·79
English	42·57	German	35·15
Oak (American)	42·32	Russian	34·28
Australian	39·78	Swedish and Norwegian	34·16
Union	39·10	Italian	32·21
Austrian	38·58	South American	31·26

Table XII.

Portion of original weight when dried at 160° *F., lost when washed and re-dried at* 160° *F.*

French	14·9 per cent.	Swedish and Norwegian	7·5 per cent.
English	14·5 „	Union	7·0 „
Austrian	12·2 „	German	6·9 „
South American	11·1 „	Hemlock	6·4 „
Oak (American)	9·4 „	Russian	6·1 „
Italian	7·7 „		
Australian	7·4 „		

It will be seen, in comparing Table V. with Table XI., that there has been a considerable change. The English, which was, before being washed, considerably the heaviest, has lost so much weight in washing as to fall below the hemlock, which was originally third and is now first.

This loss has nothing to do with the effect of drying, for the samples were equally dry in each case. It represents a certain amount of soluble matter which is contained in the leather, and which, in a country subject to continual or occasional rains, must sooner or later be washed out of the soles of shoes or boots worn out of doors, even if not washed out by the manufacturer. It represents in part the material which stains the stockings when new boots or shoes are worn. In that case, it is, probably, sometimes dissolved by the perspiration of the feet. Some of the leathers, particularly the English and the French, seemed to contain a substance like clay, which was washed out with difficulty. In dry climates, or in the case of boots and shoes worn in the house, this filling might never be washed out, and, remaining in the soles, would certainly increase the resistance to the absorption of water, and might possibly increase the resistance to attrition or wear.

The figures in Table XIII. are the specific gravity, or the relative weights of the fibres of the leather and an equal volume of pure water.

The following is the method of computing, from the weight in water and the weight of the dry fibre, at 160° F.:

Example.—Oak, No. 8038:

Weight of sample dried at 160° F., washed and re-dried	40·61
„ „ in water	13·07
Difference, being the weight of an equal volume of pure water	27·54
Specific gravity, $\frac{40·61}{27·54}$	1·476

This calculation was repeated for every specimen, and the mean taken as the specific gravity of that kind of tannage. It will be seen further on that the specific gravity of the green hide is 1·39; and as the specific gravity of all the specimens of leather is more than this, and as the specific gravity of those pieces which are obviously the best tanned is the highest, I presume that the more tannin is united with the hide the higher will be the specific gravity.

Table XIII.

Mean specific gravity of the washed, dried at 160° *F. Fibre of various tannages.*

English	1·5200	Austrian	1·4644
French	1·5145	Russian	1·4587
German	1·4885	Union	1·4564
Swedish and Norwegian	1·4792	Australian	1·4457
Oak (American)	1·4724	Italian	1·4422
Hemlock	1·4668	South American	1·4125

In order to facilitate comparison, Table XIV. has been competed from Tables III., VI., and XII.

TABLE XIV.

Mean weight of that portion of a square foot of leather, originally $\frac{1}{4}$ inch thick, remaining after all soluble matter is washed out, and the residue dried at 160° F.

	Pounds.		Pounds.
French	1·230	Austrian	1·030
Hemlock	1·143	Oak (American)	1·016
German	1·092	Australian	0·999
Russian	1·055	Italian	0·962
Union	1·043	English	0·949
Swedish and Norwegian	1·032	South American	0·899

After the specimens were all washed, soaked, and weighed, as given in Table X., but before being dried, as given in Table XI., they were all subjected to a uniform pressure of two thousand pounds per square inch, being $12\frac{1}{4} \times 2{,}000 = 24{,}500$ pounds on each piece. This pressure was selected as being about equal to that applied in practice in rolling. It was applied to them by placing them under the Riehle testing-machine in the Machinery Hall. The force was applied in this machine by a hydraulic press, but the pressure was measured by a scale-beam, as in an ordinary platform scale. The two compressing jaws were of iron, and planed parallel. They were opened 18 inches, and a block of wood 9 inches by 9 inches, and 16 inches long, with ends sawed square, was placed on end on the lower jaw, and an iron plate, turned true, 8 inches in diameter and 2 inches thick, laid on this block. This arrangement allowed the lower jaw to accommodate itself to the leather, which was usually a little thicker on one edge than the other, and to press equally over the whole surface. The samples were then placed successively under this machine, and the hand-pump worked until the scale-beam indicated a pressure of 24,500 pounds (11,113 kilos.), being two thousand pounds per square inch (1,406 kilos. on the square millimetre), which took about one half minute. The machine was then stopped, the pressure relieved, the specimen taken out, and another substituted. During the time the pressure was being applied, the water was forced freely from the samples. When the pressure was relieved the leather did not appear to recover its original thickness, but remained as pressed, being, perhaps, three-fourths as thick as when wet. The samples increased in size from $3\frac{1}{2}$ inches to $3\frac{3}{4}$ inches square, under the combined influence of the pressure and the water, and shrunk, after being dried, to about $3\frac{3}{8}$ inches square, returning, however, when exposed to the natural atmosphere, to their original size of $3\frac{1}{2}$ inches. After being taken from the testing-machine, the samples were dried at 160° F., with the result already given in Table XI.

The object of this compressing was to be sure all the specimens were equally hard in the experiments which were to follow. It was considered that all specimens had been relaxed under the influence of the water and rubbing, and that a perfectly equal and a perfectly even pressure on all would bring them into the same state of hardness or compactness.

The next experiment after drying, the results of which are given in Table XI., was to determine the rapidity with which each specimen would take up water. This was done by dipping each specimen singly into water, and allowing it to remain ten seconds, taking it out, wiping it off on a damp cloth, and weighing it carefully. This was repeated twenty-three times for each piece of leather. The whole time each piece was under water was therefore $23 \times 10 = 230$ sec. $= 3$ min. 50 sec. The wiping off and weighing occupied about one minute for each experiment, so the whole time occupied by the whole experiment was about twenty-seven minutes. Generally the samples were nearly saturated during the twenty-three dips, and in some cases were saturated before the twenty-third dip was reached, so that during the last few dips the weight did not increase. The mean results of this experiment are given in the Appendix, but the mean results for each kind of leather are given in Table XVI. The unit of weight is the weight of the leather at the time it was dipped, being the weight of the washed sample dried at 160° F., and including the moisture it had absorbed in the interval elapsing between the time it was weighed after being dried, and the time it was dipped, which interval varied from six hours to two weeks.

TABLE XVI.

The mean relative weight of samples of leather of various tannages, the weight when washed and dried in open air being 100, *after successive immersions in water during an interval of ten seconds, as follows:*

Number of Immersion.	Oak.	Hemlock.	Union.	English.	Austrian.	Australian.	Italian.	German.	Russian.	Swedish and Norwegian.	French.	Raw Hide.
0.....	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
1.....	107·2	101·1	103·3	102·1	112·1	104·0	105·0	105·7	103·6	108·6	106·7	102·1
2.....	111·0	105·0	105·8	104·6	117·2	108·4	108·9	109 0	107·7	113·8	110·6	103·6
3.....	114·5	107·4	108·5	106·7	120·2	112·3	112·1	111·6	111·2	118·0	113·3	104·6
4.....	116·2	109·8	110·1	108·9	122·7	115·4	114·8	114·0	114·5	120·9	115·3	105·9
5.....	118·7	112·0	112·1	111·3	121·2	117·8	117·5	115·7	117·3	123·5	116·9	106·2
6.....	120·4	113·9	113·9	113·3	126·4	119·8	119·1	116·9	119·1	125·3	118·3	106·2
7.....	122·2	115·5	115·8	115·1	127·9	121·7	121·9	118·9	120·9	127 0	119·5	106·4
8.....	123·0	117·1	117·6	116·8	129·2	123·0	123·8	120·1	123·7	128·2	120·6	107·0
9.....	124·1	118·5	119·3	118·3	130·4	124·7	125·5	121·7	125·4	129·3	121·4	107·6
10.....	125·3	119·5	122·6	119·7	131·4	125·2	126·9	122·8	127·1	130·3	122·0	108·2
11.....	126·2	120·7	122·0	121·0	132·3	126·1	128·2	123·9	128·2	131·4	122·6	108·7
12.....	127·1	121·5	123·3	123·0	133·0	126·8	129·2	124·3	129·7	131·7	123·1	109·3
13.....	127·6	122·1	124·3	124·6	133·9	127·5	130·3	125·7	130·9	132·2	123·6	109·3
14.....	128·1	122·8	125·3	126·3	134·4	128·0	130·3	126·4	131·1	132·6	124·1	109·6
15.....	128·6	123·4	126·2	127·4	134·9	128·4	131·4	127·1	132·9	133·0	124·3	109·6
16.....	129·1	123·9	127·3	128·8	135·6	128·8	131·9	127·6	133·3	133·4	124·7	110·7
17.....	129·5	124·1	127·9	130·3	136·2	129·0	132·3	128·4	134·5	133·7	125·0	111·0
18.....	129·9	124·2	128·7	131·4	136·5	129·2	132·8	128·8	135·4	134·0	125·3	111·0
19.....	130·2	125·0	129·3	132·9	136·9	129·5	133·0	129·1	136·0	134·3	125·5	111·0
20.....	130·5	125·0	129·9	134·3	137·3	129·7	133·4	130·3	136·1	134·6	125·7	111·0
21.....	130·7	125·6	130·7	135·8	137·7	129·9	133·6	130·7	136·9	134·8	125·9	111·0
22.....	130·8	125·8	130·9	137·3	137·9	130·0	133·7	131·0	137·1	134·9	126·0	111·0
23.....	130·9	125·9	131·1	138·7	138·2	130·0	134·0	131·2	137·7	134·9	126·1	111·0

The amount of water taken up by the samples during their twenty-three immersions is perhaps as fair a measure as any of the relative absorption of various kinds of leather, when used for the soles of shoes. It is a measure of the amount of water that will be taken up, in the same time, under the same circumstances, by various kinds of leather. The relative amount, compared with the weight of the sample before being immersed, is given in the last line of Table XVI. The same, compared with the weight of washed and dried leather, is given below:

TABLE XVII.

Mean weight of samples of leather after twenty-three successive immersions of ten seconds each, and relative value of the same compared with the weight of the same when dried at 160° *F.*

	Absolute.	Relative.
Raw hide	21·70 grammes.	111·0 per cent.
English	59·15 „	138·9 „
Hemlock	63·69 „	147·6 „
Union	57·88 „	148·0 „
Oak (American)	62·67 „	148·1 „
Australian	58·90 „	148·2 „
German	52·06 „	150·4 „
Italian	48·97 „	152·0 „
French	58·15 „	153·9 „
Russian	53·60 „	156·4 „
Swedish	54·87 „	160·1 „
Austrian	64·46 „	167·1 „
South American	58·80 „	188·0 „

One would expect the leather which weighs the least per square foot, for a given thickness, and in which the fibres are the most dense (*i.e.*, having the greatest specific gravity), would be the most porous, and therefore would take up water the fastest. The Austrian leather is, at the same time, the lightest, and has the highest specific gravity, and that leather does take up water the

fastest, and takes the most of it. Conversely, one would expect the leather which weighs the most per square foot, for a given thickness, and which has the lowest specific gravity, would take up water the slowest and the least. The hemlock leather is, at the same time, the heaviest per square foot, and has the lowest specific gravity, and does take up water the slowest, and takes the least. The experiments on rapidity of absorption, then, are entirely in accordance with a rational expectation.

Arranging the leathers in the order of the weight of the washed and dried square foot:

TABLE XVIII.

Mean weights and specific gravities of a square foot, ¼ inch thick, of various tannages.

	Weight.	Sp. Grav.
French	1·162 pounds.	1·5145
Hemlock	1·143 „	1·4668
German	1·092 „	1·4885
Russian	1·055 „	1·4587
Union	1·043 „	1·4564
Swedish and Norwegian	1·032 „	1·4792
Austrian	1·030 „	1·4644
Oak (American)	1·016 „	1·4724
Australian	0·999 „	1·4457
Italian	0·962 „	1·4422
English	0·949 „	1·5280

A comparison of this table with Table XVI. will show that in every case where one leather is at the same time lighter per square foot, and has a heavier specific gravity, it will absorb water faster, and will absorb more than another. This is true of every leather except the English.

If the two classes be separated we have as follows:

Class I. takes up water rapidly (A., S., O., F., and A.)

Mean specific gravity	1·4925
Weight of a sq. ft.	1·0 pounds.

Class II. takes up water slowly (H., U., and G.)

Mean specific gravity	1·4712
Weight of a sq. ft.	1·093 pounds.

These differences are not great, but they are in the direction indicated.

From an inspection of the results of the experiments on individual specimens of leather, it will be seen that there is a greater variation among the hemlock leathers than any other. If this tannage be divided into two classes, as before, we have:

Class I. takes up water rapidly (Nos. 13–20–12).

Mean specific gravity	1·470
Weight of 12¼ sq. ins. ¼ in. thick	43·69 grammes.

Class II. takes up water slowly (Nos 21–16–15–30–31).

Mean specific gravity	1·461
Weight of 12¼ sq. ins. ¼ in. thick	44·58 grammes.

The same is true of the union:

	Class I.	Class II.
Numbers	28–30	34–32–36–37
Mean specific gravity	1·473	1·456
Weight 12¼ sq. ins. ¼ in. thick	39·22 grammes.	39·80 grammes.

The same is also true of the oak:

	Class I.	Class II.
Numbers	0, 1, 2, 5, 6, 7	11, 4, 3
Mean specific gravity	1·480	1·472
Weight 12¼ sq. ins. ¼ in. thick	40·72 grammes.	38·20 grammes.

It appears, then, that this law holds true among different samples of the same tannage as well as among all the tannages of different countries and

among different tannages of the same country. It probably, then, has some other cause than the different kinds of bark used.*

Resistance to Abrasion or Attrition.—An experiment was made to determine this quality, but with imperfect success. The machine used for that purpose consisted of a fine-grained Ohio sandstone, intended to be used as a grindstone. It was mounted on a vertical axle like a millstone, and revolved at the rate of 75 revolutions a minute. The pieces of leather, after having been washed, dried, &c., as already described, were tacked on wooden blocks by four screw-pegs in each piece. These wooden blocks were portions of an annular ring 30 inches outside diameter and 23 inches inside diameter. The whole number of segments necessary to complete the ring was twenty. Only eight blocks were used, which were spaced equidistant around the circumference of the stone on the upper face. These were kept from revolving with the stone by chocks screwed on the frame-work of the machine. These chocks were so shaped that they did not crowd the wooden block and the leather tacked on it down on the face of the stone, but only prevented it from revolving with the stone. The blocks were laid on the stone with the leather *down*, and an iron weight laid on them. The leather then being pressed down on the stone by the weight and rubbed by the stone revolving beneath, it would in course of time be worn away. The whole weight pressing down upon the leather was 6¼ pounds (2·83 kilos.), being (6¼÷12½=)½ pound per square inch (0·35 kilos.=per. c^2). The diameter of the stone was 30 inches (0·762 metres), and its velocity nearly 75 revolutions per minute. The speed of the rubbing surface was therefore nearly 500 feet (152·4 metres) per minute, or 5½ miles (8·8 kilos.) per hour. The stone was driven by a 5-inch (12·5 centimetres) belt on a 30-inch (0·762 metres) pulley through a pair of mitre-wheels from a 15-inch (0·381 metres) pulley on the line shaft. This belt often slipped, although very tight.

It was expected that this machine would offer an exact means of determining the relative resistance of the various kinds of leather to attrition or abrasion. The experiment was not perfectly successful for the following reasons:

On the first trials, the surface of the stone soon after being started became glazed by the dust ground off from the leather, working into the pores of the stone and filling them up, until the surface was as smooth as polished glass; in this condition it did not cut away the leather at all. This difficulty was overcome after many trials by allowing a little stream of fine sand to fall on the centre of the stone through an orifice in the bottom of a box, which was scattered uniformly over the surface by the centrifugal force. The quantity of sand used was about four quarts per hour. This removed the difficulty from glazing, but the effect of the sand rubbed on the stone by the leather was to cut away the stone much faster than the leather. As the stone wore down it became softer and cut away the leather much faster than at first, and although the surface was trued up at the end of each experiment (lasting two hours and grinding seven pieces), it would become full of furrows and hollows before another experiment was completed.

The friction of the leather on the stone heated both the stone and the leather from a temperature of 80° at the commencement to a temperature of from 140° to 180° in different experiments at the end, and possibly burned the leather a little. The result of these variations was to vary the weight of the leather worn away in the proportion of 100 to 400 for different specimens at different times, and to destroy all value of different experiments for comparison among themselves.

It would appear that to make such an experiment perfectly successful, the revolving disk should be a perfectly uniform material through that portion of

* I presume this arises from the different methods of preparing the hide. If treated with lime the fat is saponified, and may be washed out with water. If the hide is "sweat" a considerable portion of the fat might remain in the hide. This fat would go to fill the pores of the leather and make it heavier per cubic foot, as well as of a lighter specific gravity. I am told that the hemlock leather on exhibition is generally "sweat leather," while the oak is generally "limed." If it should prove to be true that the hemlock leathers which took up water fast were limed, and the reverse, the question would be settled. This would also account for the fact that the "gains" are greater in hemlock leather, while there appears to be more tannin combined in the oak. Note.—This has not proved to be true.

the depth of surface which would be worn away (such a uniformity could probably be obtained with a cast-iron plate); and that some means should be provided for keeping the surface cool, either by circulating water through a hollow plate or by allowing a little stream of water to play on the under side of the plate, thus keeping the lower surface wet and cool, and conveying the heat away from the upper side through the plate.

As the machine was manipulated during these experiments, seven pieces of leather were placed on it at the same time, and ground for two hours. During these two hours the seven pieces were changed in position every fifteen minutes so that at the end of the two hours every piece had occupied every place and had been under every weight.

There would appear to be no reason why the weight ground away, under the circumstances, from each of these seven pieces, should not be in proportion to the resistance to attrition or abrasion.

The table appended to this report shows the date and hour of grinding and the weights lost by each piece. If the various pieces of oak, union, and hemlock leather *ground at the same time* are compared, we have the following, as in Table XIX.

It will be observed that the figures representing relative wear are in the same direction as the specific gravities (which I assume to be an indication of the amount of tannin combined with a unit of hide), the leather having the highest specific gravity (and, therefore, presumptively the greatest amount of tannin in combination) showing the greatest endurance.

The following table shows the hours and date of grinding of each piece, being compiled from the Appendix to show which pieces were ground together:

TABLE XIX.

*Showing which pieces were ground on same day and at same hour.**

Date.	Hours.	Numbers of Samples Ground.
August 9	P.M.	23– 24– 41– 44– 52– 60– 70– 71
„ 10	A.M.	0– 1–*13–*20–*27– 32– 34–*38
„ 11	P.M.	*6– 16– 21– 37– 54– 64– 35– 60
„ 12	—	5– *8–*11– 14– 17–*18–*30– 40
„ 14	A.M.	2– 10– 15– 31– 33– 36– 53– 61
„ 14	P.M.	4– 7– 12– 28– 42– 50– 55– 45
„ 15	P.M.	3– 22– 51– 57– 58– 65– 72– 73
„ 16	A.M.	25– 26– 43– 46– 47– 48– 62– 63
„ 16	A.M.	67– 68–*18– 56–*27 *66– 34– 37
„ 16	P.M.	*6–*11– *8–*13–*20 *38–*30– —

By comparing those pieces ground on same day, a fair estimate of the relative endurance may be obtained.

TABLE XIX. A.

Mean weight lost in grinding in same time by the oak, hemlock, and union leathers.

Date.	Weight lost in grinding Two Hours.		
	Oak (American).	Hemlock.	Union.
August 10	8·04	7·32	8·25
„ 11	6·04	10·63	8·49
„ 12	8·65	8·90	7·77
„ 14	12·28	12·48	11·21
„ 14	9·96	9·22	14·40
„ 15	5·49	5·70	6·13
Mean	8·41	9·04	9·30
Relative	100·0	107·5	111·5

* Those marked * are ground twice.

That is to say, the mean weights of the leather worn away under the same circumstances, when washed and dried at 160° F., will be :

Oak - 100·0 | Hemlock - 107·5 | Union - 111·5

The above figures do not indicate the proportionate amount of leather in the condition exhibited that will be ground away under the same circumstances, for the oak loses more by washing and drying than the union or hemlock. The 100 parts of washed and dried oak leather worn away will be represented by 122·3 parts of leather in its original condition, the 107·5 hemlock by 127·7, the 111·5 union by 134.2. The relative amounts worn away then will be in the original leather in the proportion of 122·3, 127·7, and 134·2, or

Oak - 100·0 | Hemlock - 104·4 | Union - 109·7

And the relative endurance,—

Oak (American) - 100·0 | Hemlock - 95·7 | Union - 91·1

In order to make these experiments complete, I have experimented upon some pieces of raw hide.* All the samples were cut from the same portion of the hide as the samples of leather, just over the kidneys. A, B, C, and D were from a green salted hide. E, F, G, and H were from a dry South American hide. J and K were also from a dry South American hide. The first eight pieces were all soaked for a week in a strong solution of slacked lime. At the end of that time the green hide was found to be so much softened that the hair and grain could be easily scraped off. The hair was taken off from all four, and in addition, as much of the grain as could be easily scraped off from A and B. There was some flesh and fat left on all four. Nos. E, F, G, and H, being dry hide, were not nearly so soft, and the hair and flesh were removed with difficulty. Nos. J and K were first experimented upon with the hair on, only being washed and first scraped off with a knife. In this condition they contained all the grease and oil in the natural hide that were not soluble in water. They were then soaked in a strong solution of slacked lime for forty-eight hours, and at the end of that time were so far softened that the hair and some little flesh remaining could be with difficulty cleaned off. All the hair and flesh were carefully removed. After being limed, these pieces are designated as J′ and K′. The flesh and fat from the green salted hide did not appear to be soluble in water, even after so long a soaking in lime that the hide could be punctured with the fingers.

TABLE XX.

Giving mean results of experiments on raw hide. Samples 3½ inches square (8·89 centimetres).

WEIGHT (GRAMMES).

	ABSOLUTE.		RELATIVE.		SPECIFIC GRAVITY.
	Wet.	Dry.	Wet.	Dry.	
†A	51·20	14·95	344	100	1·369
†B	46·40	13·57	341	100	1·368
‡C	60·50	19·35	312	100	1·290
†D	45·00	15·25	293	100	1·339
§E	56·20	20·70	271	100	1·400
F	52·10	19·30	269	100	1·389
G	54·35	19·13	284	100	1·389
H	45·00	16·00	281	100	1·386
J	48·67	24·90	195	100	1·369
K	46·70	24·55	187	100	1·368
J′	46·16	21·62	223	100	1·390
K′	44·50	20·92	213	100	1·390

* In the ordinary experiment of having a pair of shoes made, one with a hemlock sole and one with an oak sole, the fact is usually lost sight of that, as the soles are originally of the *same thickness*, the hemlock sole weighs about 12 per cent. the most.

† A, B, and D had a little fat on them when dry.

‡ C had considerable fat, probably at least (19·35—15·25=) 4·10 grammes more than D.

§ E was put into a hot solution of lime.

The following is the result of those experiments :

1st. Thoroughly limed and partially cleaned green salted hide (A and B) has specific gravity of 1·3685, and will absorb $2\frac{1}{2}$ times its weight of water.

2d. Thoroughly limed green salted hide, thoroughly cleaned on hair side and partially on flesh side, has a specific gravity of 1·3, and will absorb twice its weight of water.

3d. Partially limed and thoroughly cleaned dry South American hide has a specific gravity of 1·388, and will absorb $1\frac{3}{4}$ times its weight of water (F, G, and H).

4th. Dry South American hide, with hair on, not limed, and only washed and cleaned with knife, will have a specific gravity of 1·3685, and will absorb nine-tenths of its weight of water (J and K).

5th. Some pieces of dry South American hide will, after being thoroughly limed and cleaned, lose fourteen per cent. of weight, will absorb $2\frac{1}{4}$ times their weight of water, and will have a specific gravity of 1·390 (J′ and K′).

It will be observed that pieces of dry South American hide, before being limed, after flesh is scraped off, weigh :

J	24·90
K	24.55
Mean	24·72

and that some pieces, after being limed, weigh, when freed of hair, flesh, and fat :

J′	21·62
K′	20·92
Mean	21·27

and that, therefore, the loss of fat and flesh through liming (including weight of hair, which must be insensibly small=24·72−21·27) is 3·45 in an original weight of 24·72, or a loss of fourteen per cent. of the original weight.

It will be also noticed that the pieces of dry South American, before being limed (J and K), weigh nearly the same when worked after being limed (J′ and K′), from which the inference would be, if the hides were not dried and weighed, that the loss of weight by liming had been insensibly small. This inference would, of course, be incorrect.

All remarks in regard to dry hide apply to hide dried at 160° F.

From these results I conclude that thoroughly cleaned, raw hide may be, without sensible error, assumed to have a specific gravity of 1·390.

Very respectfully,

THERON SKEEL.

GENERAL REPORT

ON

GROUP XIII.

PAPER INDUSTRY, STATIONERY, PRINTING, AND BOOK-MAKING.

JUDGES.

American.

Mr. James M. Willcox, Philadelphia, Pa.
Mr. C. O. Chapin, Springfield, Mass.
Mr. Wm. Faxon, Hartford, Conn.
Mr. Edward Conley, Cincinnati, Ohio.
Mr. H. T. Brian, Washington, D.C.

Foreign.

Sir Sydney H. Waterlow, Bart., M.P., Great Britain.
Mr. G. W. Seitz, Wandsbeck, near Hamburg, Germany.

GENERAL REPORT.

PAPER INDUSTRY, STATIONERY, PRINTING, AND BOOK-MAKING.

On entering upon our duties in the examination of the various classes of objects allotted to the Judges of Group XIII., a cursory glance over the entire Exhibition greatly impressed us with the magnitude of the work before us. No less than sixteen classes confronted us, some of which included many hundreds of objects; and the entire examination must, of necessity, extend over many thousands. The exhibits in Class 258, embracing stationers' articles, were very numerous and from many parts of the world; and, although very interesting, they brought to light little that was entirely new. Perhaps there is little room for absolute novelty in this class; but the ingenuity and skill displayed in perfecting the various articles that composed it were very apparent. Of fancy note-papers, envelopes, cards, &c., there was an endless variety, gotten up almost invariably in good taste, and made of the best material. The gold and steel pen manufacture seems nearly to have reached perfection; and the same may be said of every variety of brush, crayon, and pencil. The best pencils are still brought from abroad; but one line of articles made from American graphite was of great excellence, and bids fair to equal, in a short time, the best heretofore imported. The ink-stand has not yet reached perfection, and this fact seemed to be realized by manufacturers, who in their efforts have displayed an almost endless variety, and who pressed upon us with assiduity the superior claims of quite a number. India-rubber enters largely into this class, but the Exhibition has shown no very recent important extension of its uses for stationers' articles.

Within the past hundred years the manufacture of paper has been so much improved as to have undergone a complete revolution. Even during a considerable portion of the present century the bleaching of coloured stock was impracticable; white paper was made from stock that came white into the mill; and the "beating" was accomplished by pounding in a mortar. All paper was made by hand, upon "moulds," in separate sheets; and white paper was quite costly. A hundred years ago only "laid" paper was known,—paper made upon moulds laid with parallel strands of coarse brass wire. Woven metallic wire-cloth was not manufactured for paper-makers' use. About ninety years ago woven wire moulds were first introduced, and paper made upon them was called "vellum." In all books and instruments of writing a hundred years old parallel water-marks made in the paper by the coarse laid wires are distinctly visible. The wire-cloth was the first step towards manufacturing by machinery. The "Foudrinier" machine has taken the place of hands, and now runs out a web of paper six or seven feet wide at the rate of thirty or more yards per minute. The coarsest and deepest-dyed stock comes, in its roughest state, to the paper-mill, and is there made clean and white. Stacks of straw and logs of wood are reduced to fine white fibre; the pulp is sized before it is formed into sheets; and, with a few "roll" beating engines and one Foudrinier machine, a paper-mill now turns out daily as much paper as could be made by twelve ordinary mills, with as many vats, a hundred years ago.

Class 269, embracing all varieties of the finer qualities and styles of paper, was well represented, and the exhibits were very gratifying. In this class a marked difference was observed between the American papers taken generally, and those taken generally from abroad. A keener competition in the manufacture of fine paper has, for some years, existed here than elsewhere, resulting in a greater perfectioning of some qualities of paper; and a greater refinement in the various styles of presenting them to the market is quite apparent to the displays of American manufacturers. Among these qualities are, conspicuously, heavy letter and note, cap, and ledger papers; above all the last. These papers, as produced by leading American manufacturers, were found to be made invariably of the best and best-mixed stock, of unexceptionable colours in white and blue, of generous thickness, and sized with animal sizing in the sheet.

The low rate of postage in the United States has, no doubt, encouraged the production of thick writing-papers pleasant to use; and the enormous American demand for large blank-books has stimulated the competitive manufacturers of these to demand of the paper-makers the best quality of ledger paper that can be made. This demand is admirably supplied, and the exhibits of American paper of this character called forth expressions of admiration from many foreign visitors. The foreign papers generally, on their side, displayed some points of excellence over the American. Owing to higher rates of postage in other countries, their writing-papers have been for many years made exceedingly light; and European manufacturers have, almost universally, attained to greater perfection in very light papers. The Exhibition has not indicated any important departure from the old rule of very thin letter paper that has so long obtained in Europe. In Great Britain, France, and Germany, particularly, great skill and science have been directed to producing the best grades of paper from inferior stock, and manufacturers there have thus cheapened the cost of good paper. In the colours and tints of their fancy papers they have reached great perfection, and in these points they excel American manufacturers. The Russian papers were found to be of excellent stock, which seems to abound in that country, and the Russian exhibits were good. The Italian papers in the Exhibition were nearly all hand-made, of good stock, good colour and texture, very strong and serviceable, but of lower finish than most others. Some of these were of remarkable size for hand-made paper, and showed great skill in hand-manufacturing. The exhibit of Spanish papers was large and varied and contained much excellent paper. The cigarette papers were remarkable for fineness, strength, and other qualities that show a thorough knowledge upon the part of the manufacturers of the taste to which they have to cater. Nearly every Spanish exhibit contained specimens of cigarette paper; and it is worthy of remark that nearly every paper exhibit from the Continent of Europe, from Spain to Russia, contained excellent paper of this kind.

The only specimens of photographic paper shown came from France and Germany. This paper is difficult to perfect, and its points of excellence have not been much studied by American manufacturers. It is necessary that it be perfectly free from particles of iron and steel, no matter how minute, as these would be developed into stains by the regular treatment it has to undergo in the photographer's laboratory; and the American plan of beating the stock with a steel-armed roll upon a steel bed-plate, precludes the possibility of having the paper absolutely free from liability to iron-stain. When any one of our mills shall adopt the expensive European plan of using brass exclusively instead of iron or steel, there need be no serious difficulty in manufacturing the best of photographic paper. A feature in which nearly all European manufacturers excel is in pulp or engine-sizing. In this they leave American manufacturers far behind. It is noticeable that, whereas the latter size all their best and medium writing-papers in the sheet with glue sizing, the former produce a very hard-sized paper by the cheaper process of pulp-sizing. This process should receive greater attention in our country, and there is no good reason that the medium grades of American writing-paper should not be produced in mills that do not possess drying lofts, as in older countries.

In confirmation of my views regarding American blank-books and paper, I am glad to be able to present those of Mr. Gustav W. Seitz, of Hamburg, Germany, one of my associate Judges, and a gentleman of great experience and accurate judgment. These have been given me in the form of a letter; and, as the whole communication is in reference to the work of our group I transcribe it entire.

PHILADELPHIA, July 24, 1876.

"JAMES M. WILLCOX, Esq., President of Group XIII.,
International Exhibition, Philadelphia.

"DEAR SIR,—In compliance with your request to name such articles observed by me as were worthy of special notice on account of their excellence, I beg to state the following regarding American exhibits. The binding of books, as well as the manufacture of blank-books, is, as to solidity and execution, decidedly the best that I have seen in the Exhibition. The same judgment applies also to plain and illustrated printing, which in beauty and

clearness, by using the best materials (paper and ink), can compete with anything displayed. It is quite natural to make mention here of the imprinting machines, which, being mostly constructed in a very ingenious way, aid very largely to accomplish such work.

"The patterns and castings of the types also are elegant and worthy of being copied; and, all considered, I can well assert that the graphic arts in the United States are at the height of the times. It is, of course, not my intention, in giving this testimony, to undervalue the merits of my own and other nations; yet it is true that no department is as well represented, comparatively, as the American. It is an agreeable surprise to me to become acquainted with the above-noted facts, which so clearly show the progress made by America in the graphic arts, and I shall not fail to make them known in Germany, being confident that many will be benefited thereby.

"I remain, dear sir,

"Yours very respectfully and sincerely,

"Gustav W. Seitz.

One feature, as I have stated, in which the European manufacturers of paper excel, is the variety and excellence of their colours in fancy papers. A longer experience in this line, and a necessity to cater to a greater public taste for fancy papers, have placed them quite in advance of our manufacturers in this art; yet a great advance has been made here within a few years, and some of the American exhibits made a very handsome show of colours.

Very little bank-note paper was found; the most noticeable exhibit being that of a Massachusetts house of long standing and excellent reputation. In this character of paper American manufacturers have long held pre-eminence. This fact is probably explained by a comparison of the circumstances attending the issue of the respective paper currencies of Europe and the United States. In the former, until within a few years, no small notes were used, and the notes of large denominations circulated only among the wealthier classes. They were consequently little handled, were kept clean, and circulated but a short time, being generally retired when once redeemed at their place of issue. It was not important that the paper for them should possess wearing qualities in a high degree. In our country, on the contrary, we are accustomed to notes of small denominations; and for a very long period, among all classes of people, paper has generally been the material of currency, in denominations of one dollar and upwards; and notes have been repeatedly issued, to save cost of new ones, long after they became unfit for public use. The frequency of counterfeiting in our country rendered necessary costly engraving and printing, and American bank-notes are, compared with most others, very expensive; hence a reluctance on the part of our banks to frequently renew them. These circumstances explain the demand, on the part of the banks, that their paper should wear as long as possible; and the demand has been well met upon the part of our manufacturers. The exhibit of its special currency-paper, shown by the United States Treasury Department, in the Government Building, was entered simply as a contribution to the Government's general exhibit, and not for competition. Its special feature is a localised coloured fibre, so incorporated into the sheets as to appear only in a fixed part of each note when printed, and not elsewhere. This paper has been in use since 1869, is essentially American in discovery and manufacture, and is now used exclusively by the Government, for the bonds of the Funded Loan, the National Bank notes, and United States Treasury notes of all denominations. One interesting exhibit of paper of bank-note character turned up unexpectedly in the Mexican department. This paper was indifferently well sized and woven, but was of remarkable strength and pliability. It was manufactured from the leaf-filaments of the maguey plant (*Agava Americana*), of which a specimen, growing in a flower-pot, was brought from Mexico for exhibition. The provincial name of the plant is *Quiote*, and it is described as one of the most characteristic and common plants of Mexico, growing throughout the low valleys, where it has long been cultivated for its juice, which is made into a fermented drink. On the mountains it grows wild, and the largest plants found are near Llanos de Apan, between Vera Cruz and the city of Mexico. Somewhat resembling a cactus, and possessing spines, it spreads its long fleshy leaves to a diameter of six to eight feet, from the centre of which rises a straight stem ten feet high, tipped with yellow flowers. It is propagated by

transplanting suckers that spring up from the roots and grow vigorously. When the filaments are prepared for paper stock the leaves are hackled green, the flesh easily separating and leaving behind a good handful of fibre. I have described this plant somewhat minutely, since, from the best information I can gain, it promises to be, in the future, of great utility in paper-making, especally as I learn that it can be cultivated at a very low cost.

Of printing-papers (Class 260) the display was not great, and there seemed to be but little inducement to bring them from abroad for exhibition. Those shown from there were of a more natural colour than the American book-papers, which, to meet a taste on the part of the publishers that is not to be commended, are bleached to such an extent, and supplemented with a delicate tinging of blue and red, as to become of too dazzling a whiteness to be either pleasant or harmless to the eyes. Some displays, however, of a more natural or creamy tint, seem to promise a prevalence of better and healthier taste in the future. The cost of printing-paper is as low as it was twenty years ago, and of some classes lower. At that time the supply of raw material was getting scarce, and it seemed probable that paper would become higher every year. The necessity of the case, however, stimulated invention and developed the use of, first straw, and then wood, as partial components of printing-paper. The infecting of wood-fibre has advanced farther than that of straw; its mixture has become common in both news and book paper; and to this is due, principally, the present low prices of these papers in the market.

There were several very interesting exhibits of wood-fibre pulp for paper-makers' use, some prepared merely mechanically, by grinding wood-fibre from the block, and some by a disintegrating chemical process. That prepared in the latter way (which is by hard boiling in alkali under high pressure) is much superior, having greater length, strength, and flexibility, and being much more free from natural gum and all else that is not pure cellulose. The wood-pulp exhibited from the United States was principally from poplar; that from Sweden and Norway (the most important European exhibits) principally from pine. The latter, though less pure, had greater strength, and was the strongest that I had ever seen, which leads me to believe that the pine of those countries possesses unusual toughness of fibre, and is peculiarly well adapted to the manufacture of paper-pulp. Other interesting exhibits were made of raw materials for paper, among which was the maguey plant, from Mexico, already described, esparto and other grasses from Spain, banana-leaves and "halfa" from Egypt, and quite a series from Victoria, Australia. Halfa is a species of swamp-rush resembling esparto, growing abundantly in Egypt, and the paper made from it was fair in quality and colour. That made from banana-leaves was of a pleasing buff, natural colour, and was handsome when printed and bound.

In the Victoria department were many specimens of paper, made from various fibres, rather crudely prepared, some of which, I am satisfied, could be well utilised in the manufacture of finer papers. I deem this matter to be of considerable importance, and cannot so well do it justice as by transcribing in full the following letter to the Commissioners from Victoria, from the Curator of the Melbourne Botanical Gardens, explanatory of the exhibits of paper-fibres and various dyes; it is as follows:

"GENTLEMEN,—I have the honour to furnish, as you request, a description of the fibres, gums, resins, dyes, woods, carpological specimens, &c., prepared and sent by me to the Melbourne Exhibition, and which you have been pleased to forward to Philadelphia.

"As regards the fibres, papers, and woods, it must be admitted that they far exceed in number those sent from this establishment to former Exhibitions. The whole of the exhibits described were prepared by myself and two assistants, with but crude appliances at our command, and within eight weeks prior to the opening of the Exhibition. The greater portion of the necessaries forming the laboratory which once belonged to this department had been transferred to another branch; thus I have had to make the best of the few opportunities afforded me for preparing in so short a time the present collection. The fibres, some forty in number, were produced in a very primitive way; the branches or leaves of the plants being merely steeped in water, and afterwards combed by hand. The quality and quantity, however, of each kind thus prepared will, I trust, serve the purpose of testing their commercial value at Philadelphia.

"Many new discoveries in the way of fibre-yielding material are shown not only of Victorian native products, but those of the other colonies acclimatised here, and of exotics also hitherto esteemed only for ornamental purposes in gardening.

"Had time permitted, my collection of exhibits would have been far greater. I should have been able to collect and test the value of many plants which I know exist on the borders of Gippsland, and even nearer to Melbourne,—I mean the Macedon and Dandenong Ranges. It is almost needless for me to say that the colony of Victoria affords great facilities, both as regards soil and climate, for the cultivation of the valuable commodities which constitute fibre and paper material. For instance, the Chinese grass-cloth plant, *Bœhmeria nivea*, the New Zealand flax, *Phormium tenax*, the *Fourcroya gigantea*, the *Agaves*, the *Lagunaria Pattersoni*,—cowitch-tree of Norfolk Island; the *Yuccas aloifolia, filamentosa*, and *gloriosa*; the *Abutilons*, and *Hibiscus*, of India, China, and America; the *Sparmannia Africana*, and a host of other foreign plants all thrive as well, and in some instances better, in this colony than in their native homes.

"The samples of *Sparmannia* sent to the Melbourne Exhibition have been prepared from both the living and dried barks of the shrub. I have never read of its ever having been discovered that this plant contained a fibre of any value. Hitherto I had only known it to be interesting as an ornamental shrub, or the plant in whose blossoms the great Linnæus first discovered the sexual system in botany. My introspection of its fibrous nature, as with others now exhibited, was only gained by mere accident in a hurried attempt to collect and prepare a variety of fibres for your Exhibition; but if even one of them prove to be of commercial value—and I believe many of them will, because of their textures and the quickness of their growth—the object I have in view will be gained, as they will be a boon to the colonists. The *Sparmannia*, like the grass-cloth plant of China, as soon as cut, shoots up even in a poor soil with wonderful vigour. The canes, if I may call them such, are often as thick as one's thumb, and they average in height from six to eight feet. In good soil two crops may be safely reckoned upon in the year.

"The plants of Queensland, from which fibres have been prepared, have all been grown here, and were introduced by the late Mr. Dallachy and the Baron von Müller, my predecessors in the directorship of these gardens. Judging from the growth of the *Hibiscus heterophyllus*, *Sida retusa* (Queensland hemp), *Pipturus propinquus*, or Queensland grass-cloth plant, *Brachychiton acerifolium*, 'the flame-tree,' *Sterculia rupestris*, 'the bottle-tree,' and the samples of fibre now produced from them, the harvest to be gained by their cultivation in Victoria would be as great as in the sister colony. It may appear strange to many that plants like these and others described, indigenous to a warmer clime, should thrive as well, and even better, in this cooler one, yet there are ample proofs that such is the fact. The growth of the flame-tree, for instance (*Sterculia* or *Brachychiton acerifolium* of Queensland and New South Wales), is more rapid in Victoria than in either of the colonies mentioned, and the *bast* furnished by this tree is, I consider, superior to *Cuba bast*. This, of course, remains to be proved by those in Philadelphia, who are better able to judge of its merits, and of others which I have described in my list. But it is more singular still to observe that plants which grow side by side with these in warmer latitudes will not grow here at all, but merely exist. *Laportia gigas* is the great stinging-tree, of which I have sent samples of fibre from plants which never attain in this garden more than four feet in height—being cut down by frost every winter—yet I have seen it beside the flame-tree in the brushlands of Queensland and New South Wales attaining a height of seventy-five feet, and with a trunk more than five feet in diameter.

"The *Pipturus propinquus*, *Sterculia rupestris*, *Sida retusa*, and many others, grow as quickly here as in Queensland. Quite as good results, therefore, might be expected by cultivating these plants; but need we go farther than our own colony of Victoria for quality or quantity of fibre or paper material, when our forests teem with valuable plants suitable for their manufacture? If we only instance the *Pimelias*, *Dianellas*, *Plagianthus*, *Caladiums*, *Lepidosperma*, or 'mat-grass,' *Commersonia*, *Brachychiton populneum*, *Urtica incisa*, *Cyperus*, *Typha*, *Scirpus*, *Carex*, *Isolepis*, and the rushes *Juncus vaginatus*, *maritima*, and *pauciflora* (and there are scores of other indigenous plants equally valuable), rags need no longer be collected for paper-making, nor

introductions from other countries for cordage. With sixty millions of acres of good land included between the parallels of 30° and 39° south latitude, we can, without cultivation, reap abundant harvests of paper material, even from various species of *Eucalypti*, *Xerotes*, *Melaleuca*, *Cyperus*, and others, and, indeed, from some of the grasses which are plentiful in their midst. Our native vegetable resources are great, and should therefore be thoroughly searched up. My thirty crude samples of paper, which are sent in frames, were prepared under great difficulties, and they were only made to prove what can be done with some of our native plants. Many of them are new, but the indefatigable Mr. Ramsden, of the Victorian Paper Mills, has devoted his attention particularly to the manufacture of paper from Victorian plants, and he will, no doubt, be able to add to his collection long before the colony has been thoroughly explored.

"The dyes, forwarded in bottles, are not so numerous as they would have been had time permitted me to send out collectors; but the samples of silk, calico, and woollen material stained with them show a variety of beautiful colours, the value of which will, no doubt, be proved at Philadelphia.

"I regret to have to say that my collection of woods could not be properly seasoned. Some of them were polished within a week after they were cut from the tree, consequently many of the specimens have split from end to end.

"I have the honour to be, gentlemen,

"Your obedient servant,

"WILLIAM R. GUILFOYLE,

"*Director of Botanical Gardens, Melbourne.*"

The display of blank and account books (Class 261) was remarkably good. From Europe were specimens of books made up of very strong and excellent paper, principally hand-made, with most solid covers sheathed with metal over the wearing parts, closed with lock and key, and in every respect admirable. These were few, and the foreign display was confined almost entirely to France, Italy, Germany, and Russia, doing much credit to all. The American blank-book manufacturers, especially, but not exclusively, those nearest the Exhibition, in this city, made very large and handsome exhibits. On the merits of these I prefer to give the judgment of Mr. G. W. Seitz, of Germany, my associate Judge, who writes: "The binding of books, as well as "the manufacture of blank-books, is, as to solidity and execution, decidedly "the best that I have seen in the Exhibition."

The manufacture of papers belonging to Class 263, building-papers, has vastly increased within a few years, and many new applications of them have been made. The quality also has improved by the admixture of hemp and manila in much larger quantities. These papers are used natural or saturated with bitumen, and are sometimes printed in either water or oil colours. They cover roofs and floors, line inside walls, protect outside walls, line cisterns, underlie carpets, displace mattings and oil-cloth, dispense with lathing and plastering, and find a number of uses that increase every year. This increase is good evidence of their economy and utility; and the exhibits were, in the order of their quality and magnitude, 1st, from the United States; 2nd, Sweden; 3rd, Japan; 4th, France. The Japanese papers of this character were the strongest and best shown, being made principally of mulberry-bark, and enamelled with oil colours and varnish in the most perfect and durable manner. These were floor-papers only, and the various other species of building-papers shown by other countries were not exhibited by Japan. Very little Japanese paper is made from rags, or linen or cotton fibre; but most of it is made, in a primitive way, of materials obtained from plants which are specially cultivated for the manufacture of paper and for no other purpose. The most important of these plants is the *Kodzu*; then come the *Gampi*, the *Mitsumata*, the *Kuwa*, or mulberry-tree, the *Hi-no-ki*, a species of wild cherry, and several others unknown to us. It is the bark only of these shrubs and trees that is used, and not the woody fibres. The better qualities of paper are made in workshops arranged for that special purpose; but most of the paper of Japan is home-made by farmers, at times when their fields do not require their whole attention. Such paper as we are daily accustomed to see is manufactured from rags, and only in the regular paper-mills recently built at Tokio, and which are provided with foreign machinery.

Of Class 264, embracing wall and other ornamental papers, there was an excellent display; and it is much to be regretted that France, which notably

excels in the manufacture of these kinds of paper, sent none of her best wall-papers to the Exhibition. But one notable exhibit came from Great Britain, and it might well serve for a suggestive model to our designers of decorative paper. Sweden showed specimens from several of her principal manufacturers, among which rich and bright designs in velvet and colours were numerous. Warm tints predominated, and the patterns, not suitable for American taste, indicated the climate of the country from which they came, and would seem to accord well with a refined taste modified by the protracted winters of the far North. Italy presented a very beautiful book of patterns, from Naples, that was in keeping with the well-known Italian artistic taste. The ancient frescoes upon the recently uncovered walls of Pompeii were there reproduced with accuracy; and the finest minutiæ of all the designs had received great care and pains. These papers were well worth the study of our producers of paper decorations, and might aid in forming a true and high artistic taste. What principally distinguishes the European wall-papers generally from those of this country is that the former are mostly made up of specific designs, each very complete in itself, that court inspection and study, the general effect being subordinate to the particular excellence of the parts; while with the American papers the general effect is principal, the shades and designs more blending, and the finished details of the finest papers of Europe generally wanting. This general effect aimed at by our manufacturers is not too much at the expense of minutiæ for the prices that they are able to obtain; and it is certainly admirably produced according to their aim. Any other style would not meet their market, and their efforts are naturally put forth to perfect the styles that will sell. There are exceptions to this rule, and in one of the principal American exhibits there were perfect and cheap copies of very fine foreign designs. Nothing is here meant in disparagement of American designs, for differences in taste may well exist, are frequently radical, and are due to the unalterable characteristics of a people. The American machinery for printing wall-paper has reached great perfection, and more than twenty colours are sometimes printed from as many cylinders during their continuous operation. Very handsome specimens of decorative paper were to be seen in the German department, and Russia presented quite a number, some of which were peculiar and quite attractive.

From the Netherlands came imitations, on paper, of fine and varied marbles, of ornamental woods, and of inlaying of woods of various textures and colours, that were very perfect, and quite superior to anything of the kind found elsewhere. Correct Flemish taste and patient Flemish labour were conspicuous in these elaborate imitations. Suspended from the walls of the office of the Commissioners from Belgium were admirable imitations, in heavy embossed paper, of the old leather hangings of Malines and Cordova. So perfect were they, that close inspection only could satisfy one that remnants of these various leather decorations were not before him.

Of ornamental papers, for book-binders' use, a very fine exhibit came from New York, and two exhibitors, from Austria and Bavaria severally, presented books of patterns of marbled and other fancy papers that seemed absolutely perfect of their kind. If these could be purchased and retained in the United States they might, in the future, contribute largely to the perfecting of the products of our book-binderies.

Of paper-making machinery there were few exhibits, and all American. In this branch of manufacturing, Americans are not excelled, and this may partly account for the absence of foreign exhibits in it. Machinery of this kind, too, is heavy, and expensive to handle, and cannot naturally be expected from abroad when no hope of prospective remuneration is entertained. An entire paper-machine was in rotation in Machinery Hall, erected and run at great expense by the builder. This was critically examined by practical judges and deemed to be excellent in all its details. It contained some important improvements, and manifested an ambitious and intelligent desire in the builder to accomplish real progress. The demand in this country for highly-finished book-paper has wrought great improvements in the apparatus for super-calendering in the web; and the several such exhibits would seem to indicate that nothing much more complete need reasonably be looked for. One most important improvement in calendering machinery is of the last ten years, and consists of a stack of from eight to twelve small rolls, not of ordinary cast-iron, as of old, but of chilled iron with a surface as hard as steel. Three

exhibits of these were brought from Wilmington, Delaware, in which each roll had been separately ground and polished so accurately that the faintest glimmer of light could not pass between any two rolls when put together. So great is the accuracy obtained by the new process of singly polishing, that any two rolls of all these exhibits might be placed together and touch each other throughout their entire lengths.

The envelope-machines were equally interesting and satisfactory, and a most important addition has been made to these within a few years. Formerly the "blanks" for folding were run out by hand, and the flaps that are finally closed were gummed by a brush and dried. This was to allow the machine to make up and press together the envelopes without an adhering of the last flap when folded. The latest improvement permits the whole envelope, including the last flap, to be gummed by machinery at one process, after which it is carried some minutes through the air to dry the last flap before folding it down previously to counting and banding. This is perfectly well accomplished, and considerable labour is saved thereby. One machine cut the envelopes automatically from narrow rolls, with a minimum waste of paper, and a cheapening of the product seemed to be effected to a considerable extent by this plan. Envelopes made by the machine exhibited were very perfect, and made with great economy, and it is probable that there is little room for further improvement in that direction.

One of the most important parts of our labours was the examination of articles included in Class 540, which embraces all kinds of printing-presses. This was a study of the "art preservative of all arts," and all progress made in it ought to be viewed as important to the progress of mankind. A great number of presses for various purposes, including roller-presses for bank-note work, were exhibited, many of which were kept in pretty constant operation. Most of these were American, and the most notable foreign presses were from England, France, and Germany, all of the very best character. The immense issues of the principal newspapers of the large cities of Europe and America, and the few short hours in which they have to be printed, have demanded new facilities and greater rapidity of printing than was possible by feeding sheet by sheet. Within a few years only this demand has been supplied, and presses now take the paper in large, continuous rolls, pass it rapidly between cylinders covered with circular stereotyped plates, print both sides in quick succession, divide the broad web into two running narrow ones, cross-cut them precisely in the middle of the margins, fold each sheet neatly twice, and deposit all in rows at the rate of over twenty thousand newspapers per hour. A printing-press of this character deserves to rank among the great feats of the mechanic arts, and the three exhibited drew for many months crowds of observers, and were universally recognised as being among the wonders of the Exhibition. These three were the Walter Press from England, exhibited by Mr. Walter of the London *Times*, the Hoe press from New York, exhibited by R. Hoe & Co., and the Bullock press from Philadelphia, exhibited by the Bullock Press Co. The latter company boldly placed in competition a press of unusual width, and printed two sheets at a time of the New York *Herald*, on a roll of paper sixty-three inches wide. The web of double width was then rapidly slit in two, and cross-cut into separated sheets. The Hoe press was also double, and printed two sheets at a time of the Philadelphia *Times*, on a roll of paper fifty-two inches wide, which it then slit and cross-cut, after which it carried the separated sheets forward for an additional operation. This was the folding; and the process was effected by two folders, one on each side, folding each sheet twice, and delivering it with absolute exactness, without a single fault. The Walter press was narrower, and printed a single sheet of the New York *Times* on a roll of paper thirty-six inches wide, which it cross-cut and delivered flat. Its speed was greater than those of the wider presses, and the work of each was admirably done. The following is a summary of the competitive trial:

WALTER PRESS.

Printed the New York *Times*, size 36 by 46⅝.
Web of paper 36 inches wide.
Number of copies printed in an hour 10,455.
Number of running yards printed in an hour 13,486.
Number of square yards printed in an hour 13,486.

HOE PRESS.

Printed the Philadelphia *Times*, size 26 by 37½.
Web of paper 52 inches wide.
Number of copies printed in an hour 21,810.
Number of running yards printed in an hour 11,359.
Number of square yards printed in an hour 16,401.
Slit the web, after printing, into two sheets, and folded each sheet twice.

BULLOCK PRESS.

Printed the New York *Herald*, size 31½ by 45⅝.
Web of paper 63 inches wide.
Number of copies printed in an hour 14,856.
Number of running yards printed in an hour 9,388.
Number of square yards printed in an hour 16,372.
Slit the web, after printing, into two sheets.

For further particulars of this remarkable trial of merit, I refer to the following letter of Sir Sydney H. Waterlow, Bart., M.P., of London, one of my associate Judges, a gentleman eminently well qualified to judge of the merits of printing-presses, and who gave to those of the Exhibition a special and careful examination. The letter contains also very valuable general observations upon the printing-presses of various kinds exhibited, that should be publicly presented to that part of the community interested in such information.

"International Exhibition, Philadelphia,
July 11, 1876.

"To the President of the United States Centennial Commission:

"Sir,—The exhibition of printing-presses in Machinery Hall and elsewhere is perhaps one of the most remarkable features of the International Exhibition. It is impossible to examine them without being struck with the extraordinary excellence and completeness which characterise these exhibits. No description of printing-press is unrepresented, and many different varieties are represented by several examples and sizes from the same manufacturer.

"There are nearly sixty exhibitors, showing more than one hundred exhibits in this class, and it is a matter for congratulation that scarcely one of them is without its own excellences and special usefulness. That some are better than others is a matter of necessity; but it is for the opportunity of making comparisons between one article and another of the same class that International Exhibitions have their great value. Of the large and more powerful presses, no such collective display has ever before been witnessed, one firm alone showing no less than a dozen of their large and well-known cylinder-presses for the different branches of printing.

"For fast newspaper presses, some of them at work every day, the Exhibition has never been equaled, especially the Hoe, Walter, and Bullock presses, while the number of small job-presses, worked either by hand or power, is as encouraging as it is surprising.

"The exhibition of presses may be classified into five main divisions:—

"1st. Web presses for printing newspapers very rapidly.

"2nd. Large presses for fine illustrated work, requiring thoroughly efficient rolling and a slow, steady impression.

"3rd. Presses for printing newspapers from cut sheets, with either double or single cylinders.

"4th. Presses for small newspapers, book-work, pamphlet, and jobbing-work.

"5th. Small job and amateur presses.

"In the first division—web newspaper-presses—there are five competitors: the Bullock double press; the Hoe double press, with holder attached; the Hoe single press, with accumulator; the Walter single press; and the Campbell press. It is no exaggeration to say that no such collection of fast printing-presses was ever before brought together. Differing materially in construction, and in the various arrangements for cutting, &c., they one and all possess such marked excellences as to render them very valuable specimens of working machinery, and to entitle them to great commendation. These presses have been tested in every conceivable way, as to their general capacity, number of revolutions per hour, steadiness in running, damping, cutting off, character of work done, strength of web, time lost in putting on last plate,

changing rolls, &c. In nearly every test all the presses exhibited a high standard of excellence.

"In a run of one hour, which was by far the most critical test to which the presses were subjected, the Bullock double press printed 14,856 copies of the New York *Herald*, making 7,428 impressions; the Hoe double press, with folder attached, printed 21,810 copies of the Philadelphia *Times*, making 10,905 impressions; the Walter press printed 10,455 copies of the New York *Times* from a single set of plates, making 10,455 impressions in an hour.

"In order to arrive at the exact relative speed of each press, it is only necessary to multiply the number of copies printed during the test hour by the length of each sheet as it leaves the press, and so find out the actual length of paper actually run through the press and printed during the hour. The Hoe double press printed 21,810 copies of the Philadelphia *Times*, or 10,905 copies to one set of plates. The length of the sheet as it left the press was 37½ inches. The Hoe double press therefore ran 11,359 yards of paper. The Bullock double press ran 14,856 copies of the New York *Herald*, or 7,428 copies from one set of plates. The length of the *Herald* is 45½ inches. The Bullock double press therefore ran 9,388 yards of paper. The Walter single press ran 10,455 copies of the New York *Times* over one set of plates. The length of the *Times* is 46½ inches. The Walter single press therefore ran 13,504 yards of paper.

"During the test hour the Hoe lost 14¼ minutes in changing paper-rolls, snapping the web of paper, and melting the composition rollers. The Bullock lost 8¾ minutes changing the rolls of paper, snapping the web, &c. The Walter press lost 6½ minutes changing the rolls of paper and a break in the web. The working of the folder on the Hoe double press was very smooth and regular; the open arrangement of the folder afforded great facility for the rapid removal of a jam; and the papers were all smoothly and regularly folded. The folders worked with precision, and without a hitch throughout the test. The cutting arrangements on the three presses are probably of equal excellence.

"On the 11th of July a trial was made of the Hoe single press with the accumulator. This form of delivery has been in use most succesfully for many years, and the trial proved abundantly that the confidence which the printers of daily and weekly papers having a very large circulation have given to this machine has not been misplaced. The test continued for 36 minutes. During this time the machine produced 6,200 papers. Allowing for three stoppages, delaying 6½ minutes, the speed while running rather exceeded the rate of 12,500 impressions per hour.

"The second division consisted of large presses for fine cut work, &c. Those exhibited by Messrs. Potter & Co., R. Hoe & Co., and Messrs. Cottrell & Babcock are unexceptionally fine. Several are in practical operation, and the character of the work printed is very fairly represented by sheets of the splendid illustrations of Messrs. D. Appleton & Co.'s *Picturesque Europe* and other similar works. The printing of such delicate work, requiring as it does the greatest accuracy of adjustment and extreme regularity of working of the press, can only be executed on presses of the highest class, design, and construction.

"In the French section three excellent presses exhibited by P. Aluzet & Co., of Paris, although not in practical operation, nevertheless received a most careful examination from the Judges in the group. The presses are exceedingly well designed and constucted, and are entitled to more than ordinary commendation.

"Among the exhibits of the third and fourth divisions will be found the presses manufactured in larger numbers and more in use than any others for ordinary purposes in the printing trade; double and single cylinder-presses for printing newspapers from cut sheets, at a high rate of speed; presses for ordinary book and pamphlet-work, prospectuses, circulars, posting bills, and all the various kinds of printed books and forms required by railway companies, banks, and commercial firms. The presses are on the whole most creditable to the manufacturers exhibiting them, having been carefully constructed and well adapted to the different classes of work. Great progress has been made during the last ten years in presses of this description, resulting in greater efficiency and greater saving of labour.

"Division fifth: small job and amateur presses. The display of these presses in every variety of form, shape, and size, by a large number of

manufacturers, is the strongest indication of the growing interest, taken in the details of the art of printing by a constantly increasing number of persons not engaged in the printing business. Very many of these presses have been especially and very successfully designed to give facilities to amateurs to indulge in the very interesting amusement of printing. These amateur presses are not only well designed but low in price.

"The great variety of small job-presses has also proved most useful in general printing offices, when worked by an adept, turning out excellent work either plain or in colours, and enabling master printers to employ their boys and apprentices with great advantage and saving in cost and labour. Great care has been bestowed in the arrangements for giving perfect rolling and distribution in most of these presses, and much praise is due to the several makers for the creditable manner in which they have been turned out.

"A most careful examination has been made by the Judges in Group XIII. of all the various classes of printing-presses; and, as some evidence of this, and for detailed explanations of the special merits of particular presses, I refer to the large number of reports in this class sent in by the individual Judges of the group.

"I cannot conclude these few remarks without congratulating the authorities of the Centennial Exhibition on the very extensive and admirable display of printing-presses, never, I venture to think, excelled at any previous Exhibition in the civilised world.

"I remain respectfully yours,

"SYDNEY H. WATERLOW,

"*Judge for Great Britain in Group XIII.*"

The following communication received from Mr. William Faxon, one of my associate Judges, contains a very interesting history of the printing-press during the past hundred years, and I am happy to place it before you as a most valuable part of this general report.

"THE PRINTING-PRESS.—IMPROVEMENTS DURING THE CENTURY.

"Scarcely any branch of the industrial arts has received more important improvements during the past hundred years than the printing-press, and almost at a glance these improvements have been made apparent to the hundreds of thousands who have visited the Exhibition, by the admirably arranged exhibits of Messrs. Hoe & Co., and the Campbell Printing-Press Co., in each of which is shown a "Ramage" press over a century old, as well as the beautifully-constructed and rapidly-working presses of the present day. The one carries us back to the commencement of the period we are celebrating, while the other embodies the latest and greatest triumphs of inventive thought and genius.

"The construction of a printing-press followed close upon the invention of printing by blocks and movable types; but it was originally little more than upright posts connected by cross-beams, through one of which a screw worked to given the impression, with a rude arrangement for running the type under the platen. Improvements were made from time to time, the most notable of which was in 1620, by Blaeuw, of Holland; but the screw-and-lever press, with modifications of the original plan,—yet substantially as seen in our Exhibition,—was the only press in use until early in the present century, when important improvements were made in England, by Earl Stanhope, quickly followed by those of Clymer, of Philadelphia, and other inventors in this country and in Europe. The screw was discarded and combinations of levers and toggle-joints were introduced, which, with various modifications, are in use at the present time.

"The hand-press, with the aid of two men, was capable of printing only about two hundred and fifty sheets an hour upon one side, and, as the increasing circulation of newspapers demanded greater rapidity, attention was directed near the close of the last century to the construction of power or machine-presses. Wm. Nicholson, of England, in 1790, invented the first press of this description. The type was to be placed upon a cylinder, and the impression given by contact with another cylinder, as is now done in the most approved presses. Though not a success, it is indisputable that Mr. Nicholson's invention embodied many of the principles embraced in the latest connected machinery.

"From this time on improvements were constantly being devised, but it was not until 1813 that a moderately successful machine-press was constructed. On the 28th of November, 1814, one was actually brought into use in the office of the London *Times*, the paper of that date informing its readers that they were for the first time perusing a paper printed by steam upon a machine-press. This press was invented by two Saxons, König and Bauer, and gave about eighteen hundred impressions per hour. In the course of a year or two a press which printed upon both sides of the sheet was devised, and, though only moderately successful as to speed,—throwing off but about one thousand perfected sheets per hour,—its work was well done; the machine was highly prized, and it was in use for many years.

"It is not our purpose to follow in detail to the present time the various improvements in the printing-press. We have indicated the origin of and the essential ideas embraced in the several early inventions. The names of Napier, of Cowper, and of Applegarth in England, of Richard M. Hoe and Isaac Adams in this country, are prominently identified with important and essential changes extending down to our own day. The latest and crowning triumph of invention for the rapid printing of newspapers is the web perfecting press, which, with the same manual labour required a century since to produce two hundred and fifty impressions or one hundred and twenty-five perfected papers of small size per hour, now prints, in the same time, from twelve to fifteen thousand mammoth sheets upon both sides; and the presses upon which the work was and is done, standing side by side in our Exhibition, testify more impressively than words can do to the vastness and the value of improvements made during the century. The wonderful creations of the Messrs. Hoe, of the Walter, of the Bullock, and of the Campbell Companies, which have daily exhibited their powers to admiring thousands, would seem to leave little in addition to be desired in the future.

"But it is not alone in the rapid production of newspapers that improvements in presses have achieved wonderful success. The increasing taste for books, elegant in their typography both in letter-press and in illustration, has led to the invention of presses specially adapted to meet these requirements. At the commencement of the century books and papers were alike the product of the same press, and it was only by greater care in the printing and in the use of other materials that the typographical appearance of a book excelled that of a newspaper. Presses are now constructed with all necessary arrangements for producing the finest book and cut work; the strongest ink is distributed with the greatest thoroughness; the rollers are made to pass over the forms any required number of times; and a firm, square, solid impression is given, so that the printed page has an appearance of elegance and perfectness until recently quite unknown.

"The smaller job and card-presses are also an entirely new creation within the century; they are of infinite variety, are adapted for general and special work, and fill an important place in typographic art.

"Such has been the progress of improvements in the printing-press during the last hundred years,—marvellous as it seems and perfect as the machinery of the present day appears to us, seeming almost to be endowed with life, thought, and reason. It is not too much to believe, particularly when we consider the inventive genius of the age and the requirements of advancing civilisaton, that the next hundred years will witness improvements as great or greater than the last, and quite in harmony, too, with the progressive spirit of the times."

"WILLIAM FAXON."

I much regret not being able, at this late day (September 15), to see the Campbell web-press in practical operation. At several appointed times we met to see this press operating, but were always disappointed in our expectations. Great simplicity and originality are shown in its general plan; and there is a reaching after effects through almost invariably new devices. The press on exhibition shows, perhaps, the highest aims yet held by the inventor; and I am far from uttering any words in disparagement of it simply because the builder has not yet been able to overcome all the difficulties that stand in the way of perfect success. What we have seen is unquestionably a work of genius, and I cannot resist the belief that it will yet attain a marked success.

The Exhibition was rich in specimens of beautiful typography, but nothing absolutely new was noticeable except a plan for cheaply and rapidly composing titles and scripts, in letters and designs of the highest and most elaborate art. This was submitted by the Bureau of Engraving and Printing, in the U. S. Treasury Department, as an invention of Mr. G. W. Casilear, in charge of the engraving division. It is a plan only feasible in large and first-class establishments, where the highest art and skill can be commanded for the execution of original letters and designs, to be repeated; but it enables such establishments, by laying in a large store of the most perfect originals, to compose the titles and scripts of bonds, checks, certificates, bill-heads, etc., by cheaply transferring and combining these originals, instead of separately engraving every design and script that they may have to produce in the course of a large and miscellaneous business.

Several "protective" papers were submitted for our inspection and report, viz., the "National safety paper," the "Commercial safety paper," and a paper printed with Francis L. Loutrel's sensitive ink. These are specially designed to prevent the alteration of checks and other evidences of value, and are all based upon the same idea, viz., insensitive colouring that will be destroyed by any agent, chemical or mechanical, that discharges or erases the writing upon the paper, thus recording evidence of any tampering with the instrument. The papers of each party, written upon, were submitted to a rival; and, according to the best judgement of the examiners, all were fairly altered. I have always held that such devices are so many steps in the right direction, as tending to multiply and complicate the difficulties to be overcome by the owner and counterfeiter; yet, on the other hand, it is rationally maintained that any device publicly claimed to afford certain protection and sometimes failing to give it positively misleads the public, by causing them to rely upon a false security. Certain it is that men who practice fraud by raising checks are skilful experts, and may be safely matched against men of science in honourable callings; yet the latter find in no safety-paper submitted absolute defence against alteration. Of this fact we were assured by Dr. Charles M. Cresson, of this city, who stated to us, in the presence of representatives of several protective papers, that he had found none able to prevent him from altering a writing without changing the paper. It is not to be supposed that invention in this direction is exhausted, and that a partial failure, a failure to be simply perfect, is a total failure. The best that has been accomplished is very creditable, and narrows down the number of forgers to chemical experts; and enough is accomplished to promise more in the future.

The administration of the Exhibition can be congratulated upon the number and quality of the articles submitted to our group of judges. They were indeed too numerous and important to have full justice done them by our best efforts. Our reports recommending prizes for merit are not few, and attest our desire to be as just as possible to those many men of uncommon intelligence and earnestness who have expended so much time, money, and pains to contribute their productions as a part of the American Centennial Exhibition. Where we have erred in our judgment, it is probable that we have erred upon the side of liberality.

Paper-Making Machinery and Fibres.
By Edward Conley.

I have the honour to submit the following report in reference to a portion of the exhibits in Group XIII., together with a review of the fibres available for paper-making, classed in other groups.

Previous to the invention of modern paper, many different substances, all of them natural productions, were used for recording. Stone, clay, and waxen tablets, bark and leaves of trees, entrails of animals, parchment, papyrus paper, etc., were employed, each people making use of the substances most convenient to them. Papyrus paper and parchment, however, were most generally used by all the civilised nations until gradually superseded by modern paper. It is impossible to fix a certain date for the invention of this most useful article, but paper made from pulp was first in use among the Chinese, probably at a very early period in the Christian era. Thence, after a long lapse of time, it passed into Tartary, where, we are told, there was a paper-manufactory at Samarcand in 648. By the conquest of Tartary in 704, the Arabs became

acquainted with paper-manufacture, and through them it was introduced into Europe at the time of their conquest of Spain. It was also introduced into Eastern Europe through the Greeks of Constantinople, whose knowledge of it was obtained direct from Tartary. This is what is known as cotton paper, which gradually took the place of parchment and papyrus, until in its turn it was superseded by linen paper, or paper made from rags. Many attempts have been made to fix a date for this important improvement, but without success. When or where linen paper was first made it is impossible to tell; we only know that it came into use about the middle of the fourteenth century, and in the fifteenth was used almost exclusively. It is a striking and significant fact that the use of linen paper should have become general just at the time of the invention of printing, as there is no fabric so well suited to meet all the demands of the press as this. The invention of printing naturally gave an impetus to paper-making, and from that time we find the paper-making interest continually increasing. The press and the paper-mill, those two powerful agents in the advancement of civilisation, have gone hand in hand, progressing always towards greater perfection. It is, however, during the last hundred years, which have been so fruitful in improvements of all kinds with every race of civilised man, that the greatest progress has been made. In fact, from the time of the invention of modern paper, which is an aqueous deposit of vegetable fibre reduced to a liquid state, up to the close of the last century the progress in paper-manufacture was very slow. Since then the improvements have been so numerous, both in progresses and machinery, that they far surpass all that had been made during the centuries of its previous existence.

A hundred years ago the process of paper-making was so different in its details from the present time that it might almost seem a different art. Then all the paper was hand-made, as machines for making paper were not invented for some years afterwards; and the little machinery used for grinding the pulp would now scarcely be deemed worthy of the name. The stock consisted of rags, which were converted into different kinds of paper, according to their texture and colour, bleaching paper-pulp being then an unpractised art. The great increase in the uses of paper, which grew up with the advancing state of civilisation, produced a demand for a more abundant and less expensive material. By the aid of chemistry this demand has been met, and the uses of alkalies has made it possible to employ many fibres of paper stock that previously were of no practical utility. By their means fibrous substances can be thorougly disintegrated, and subsequently subjected to the modern bleaching process. Now the wood from our forests, the straw from our grain-fields, old paper from our waste-baskets and even jute from far away India, are staple materials upon which paper-manufacturers depend to keep their mills running. The rags, also, are subjected to processes at that time unpractised, if not unknown, and those that formerly would have been thought unfit for making the lower grades of paper now become stock for the finer. Not only in the processes, but also in the machinery for paper-manufacture, the improvement has been almost without parallel. From the time of the invention of the paper-machine, about the beginning of the present century, which may be truly said to have revolutionised the art of paper-making, the inventions and improvements in the machinery used in its manufacture have been so numerous that it would be a work of great time to enumerate them.

Paper-Making Machinery.

A sketch of the improvements made in paper-manufacture seems to be properly introduced by the invention of the Fourdrinier machine, for it is to this that the great change is mainly due. This was invented in France, in 1798, by Louis Robert, an employé in the paper-manufactory of Francis Didot. The credit of making the invention of practical utility, however, is due to the Messrs. Fourdrinier, of London, from whom the machine takes its name. These gentlemen, at that time extensive stationers and paper-manufacturers, greatly improved the original machine, and in 1803 bought up all the patents that had been issued in reference to it. They still continued to improve the machine until, in 1806, it was so far perfected that the cost of manufacturing paper was reduced from sixteen shillings to three shillings and ninepence the hundred-weight. Previous to the invention of this machine, paper was made in sheets limited in size by the size of the mould; now it can be made

over nine feet in width, and of any length, as the pulp passes over an endless web, and, moreover with a great saving of time and money. When paper machines were first introduced they encountered the same violent opposition that followed the introduction of machinery in general. Several machines were destroyed during the first twenty-five years after their successful introduction by workmen who had been trained to make paper by hand, and supposed that the use of machinery would take their vocation from them. Even to the present time the prejudice in favour of hand-made paper exists among some consumers, who imagine that it is stronger and better than machine-made paper. An examination of both kinds shows that the contrary is true, and that the most even, strongest, and best papers are those manufactured on machines.

The invention of the Fourdrinier machine was followed by that of the cylinder-machine. This was invented, in 1809, by John Dickinson, an English manufacturer, who is said to have been led to the invention by a desire to compete with a mill near his own in which a Fourdrinier was in operation. The cylinder-machine is well adapted to the manufacture of the coarser grades of paper, and especially to making pasteboards for the use of bookbinders and box-makers. When used for the manufacture of pasteboard, several cylinders are worked in connexion, by which means a sheet of pasteboard containing two or more thicknesses of paper may be made by one operation.

Since their first introduction machines have been very much improved; especially within the last sixty years, by the addition of several attachments. Among these may be named the pulp-dresser, for screening the pulp and freeing it from all foreign matter; the dryers or steam-cylinders, for drying the paper as it is made; and the paper-cutter, for cutting the web of paper into any desirable size.

Another adjunct of the paper-mill, known as the super-calenders, has been introduced within the last fifty years. These are used for glazing fine papers, and consist of four iron and four paper-rolls in one stack, through which the paper passes from one to three times. In the United States these have in a great measure taken the place of the plating-machines used in other countries. Ledger, flat, writing, and fine papers of all kinds, except the first grade of plate-paper, are glazed upon these machines. Within the last few years the use of chilled iron calendar-rolls has become very general. They are attached to the machine, and glaze the paper as it is made. To a certain extent these have proved successful, particularly for newspaper and the lower grades of book-paper. For the finer grades they are neither so good nor so economical as the super-calenders. When the paper is glazed as it comes from the machine, it must pass through one or more stacks of calenders, containing from seven to eleven rolls each, in order to get a high finish. The percentage of waste in this mode of glazing is sometimes very great, and materially increases the cost of production. Moreover, when the paper is glazed by one operation it must receive an enormous pressure, which gives it a greasy appearance, and, from the non-elasticity of the chilled roll, the least lump is crushed flat until it becomes a dark, transparent spot. If the paper is only partially glazed as it comes from the machine, and is then passed two or three time through a stack of super-calenders, it receives the pressure gradually, and owing to the elasticity of the paper-calender is not crushed, being in consequence much stronger and cleaner looking. For these reasons the use of the super-calenders is preferable to that of the chilled rolls where a high finish is desired.

In the mechanical preparation of paper stock many minor improvements have been made, such as cutting the rags by machinery, boiling the stock in close rotary or stationary boilers under pressure, and the use of the revolving washing-cylinder for removing the dirty water from the washing-engine. Notwithstanding all modern improvements, the pulp for the finest paper exhibited was prepared in the old beating-engine, substantially the same machine as that invented in Holland in 1750. This engine did not come into general use for many years after its invention, probably not over a hundred years ago, and during all this time its principle has remained unchanged. It is true that in the United States two patent finishing-engines, the Jordan and the Kingsland, have been put into successful operation within the last twenty-five years in many book and news-mills, and are doing good service in brushing out and finishing the pulp for the machine, yet the preparatory process of washing and

reducing to half-stuff is still done by the old Holland engine. The Gould Patent washing-engine, exhibited by the Holyoke Machine Company, is in the same class as the two above mentioned, but is constructed on quite a different principle. It has been in operation about three years, and as yet has been used but it approaches more nearly to a substitute for the old Hollander than either of the others. In its gearing and washing facilities it can still be improved, but it may be classed in the line of progress.

The paper-machine exhibited by the Gavit Paper-Machine Works of Philadelphia, which was in almost constant operation during the Exhibition, is strong and well built. It contains many improvements. and can claim to be in the front rank of first-class paper-machinery.

One very important discovery was made about a hundred years ago,—1774,—the use of chlorine gas as a bleaching agent. It was many years before its use became general, the first patent being issued in 1795. This has been of very great benefit to paper-manufacturers. By means of it the range of materials for paper stock has been largely increased, as it enables a good white pulp to be obtained from many substances that otherwise could not be used.

Caustic Alkalies.

It has been, however, within the last thirty years that one of the most important of all changes in paper manufacture has been made,—the use of caustic alkalies for subduing various vegetable fibres, as straw, wood, esparto, jute, and many others of a like kind. The great increase in the demand for paper has for many years past made the question of material a very serious one for paper manufacturers. The supply of rags, or materials partially reduced in other manufactures, was not sufficient to meet the demand, and it became necessary to find some raw fibre that could be used wholly or in part, while some agent was needed that would thoroughly disintegrate without destroying them. The use of caustic alkalies has accomplished this, and has already largely increased the supply of paper material. As the fibres of different countries become better known, it would seem to place an almost unlimited supply at the disposal of the paper manufacturer of the future. In fact, it is yearly becoming more evident that it is upon such agents as are necessary for subduing raw fibre the manufacturer must eventually depend for a supply of material. From 1858 to 1866, inclusive, there were issued in England alone 139 patents "for the use of alkalies for cleansing, disintegrating, scouring, neutralising, &c." In the patents issued from the United States Patent Office during the same time, caustic alkali is used almost exclusively for the purpose of disintegration, nor have more recent investigations found any agent to take its place.

In the United States, straw-pulp, prepared by caustic alkalies, is used to a very great extent, even in fine grades of book-paper. Three years ago the consumption of straw for white paper was over one hundred and fifty tons per day, producing between fifty and sixty tons of straw pulp. Owing to the depression in the paper trade, and the cheapness of other stock, not more than one-half as much is used at the present time. In connection with the use of straw and similar substances, it may be well to mention a mill that has been invented by Lahousse, of France, for disintegrating and bleaching these substances. The mill itself consists of a pair of sandstones, dressed and driven, like a pair of mill-burrs. The straw is first boiled under pressure in caustic alkali, and after being cleansed by washing is mixed with the bleaching liquor. A continuous stream of this pulp is then fed into the mill, the stones running at the rate of two hundred and fifty revolutions a minute. While passing through the mill, a double object is accomplished: the knots and joints in the straw are thoroughly disintegrated, and the pulp mixed with the bleaching liquor, and at the same time the friction of the stones raises the temperature to about ninety-eight degrees Fahr., at which temperature the chlorine gas is set free, and acts most advantageously upon the stock. It is the most effective machine of its kind in use. At present over sixty mills on the continent have it in active operation.

A large amount of chemically-prepared wood-pulp is also used in the United States. About ten years ago a stock company was organised which built the American Wood Paper Pulp Works at Manayunk, now a part of Philadelphia, for the manufacture of chemically-prepared wood-pulp. The works are the

largest of their kind in the world, and cost $500,000. They have been in successful operation from the start, and produce fifteen tons of dry white pulp per day. Mr. Bloomfield H. Moore, of Philadelphia, who leased these works and uses their products, exhibited a beautiful line of book and plate papers, largely composed of this pulp. These papers have a fine finish, and take an elegant impression. Several other mills in the country manufacture chemically-prepared wood-pulp. The aggregate amount produced daily in the United States is not less than thirty tons.

In the last few years several improvements have been introduced in the manufacture of wood and straw pulp, two of which are worthy of special mention.

1st. A complete circulation of the caustic liquor through the stock while boiling under pressure, also heating the liquor up to a high temperature, and expanding it before percolating the stock. This imparts the heat to the stock, and softens the intercellulose while passing through it. At the same time a separation of the non-fibrous substance from the stock is effected by the current or circulating liquor. The operation of this apparatus is as follows: An upright boiler is filled with stock, and a sufficient amount of caustic liquor is added. A cock is opened, and the liquor is allowed to flow through a perforated false bottom in the boiler into a centrifugal pump, which forces the liquor through a coil of pipe in a steam-drum, and then in at the top of the boiler and through the stock; the steam and hot water in the drum heat and expand the liquor, while the pump keeps up a complete circulation during the boiling.

2d. The other improvement mentioned operates as follows: Attached to the bottom of a stationary boiler is a disintegrator or grinding machine, constructed on the same plan as a Jordan engine. The stock from the boiler passes into this disintegrator while under pressure, where it is crushed, and all particles of the fibre are brought into contact with the hot liquor. From the disintegrator the stock passes into a pump which forces it into the top of the boiler. By this means a complete circulation is kept up, and the stock, passing through the disintegrator, is thoroughly crushed and separated, enabling the liquor to act directly upon the intercellulose without weakening the fibre.

In 1853, Richard A. Brooman obtained in England a patent for the reduction of wood to a fibrous pulp by mechanical agents. In his specifications he says: "The machinery consists of a millstone or millstones, or metal rollers, cylinders or rasps, with roughened surfaces, which are caused to act upon blocks or pieces of wood, held in a frame always in the direction of the grain thereof," a current of water being directed on to the reducing agent "before its contact with the wood." Henry Voelter, a German, improved this machine and introduced its product, which is known as mechanically-prepared wood-pulp, into Europe and America. Other machines have since been invented for the same purpose and applied in this country. During the last ten years this kind of paper stock has come into general use both in America and in Europe for the lower grades of book and news paper. It has greatly cheapened the production of paper, and answers the public wants for every-day purposes. It is much to be regretted, however, that the natural saps contained in the wood—it being used in its green state—are very detrimental to the durability of the paper, particularly when it is excluded from the air between the covers of a book. Books and newspapers printed upon such paper will in time mould and decay; hence books intended to record the world's progress for the use of future generations, or even newspapers that are filed away in libraries, should not be printed on such paper.

The improvement in the use of imperfections or old printed and written paper has been very great in the last fifteen years, probably more than in the sixty years from the time when Matthias Koops first practically used them for making white papers in 1801. It is mainly to Americans that the world is indebted for the utilization of this waste product. During our civil war paper stock became so dear that American manufacturers were forced to work over old paper in order to keep their mills running. This was done by boiling the old papers in a solution of alkali, to destroy the ink, and then piling them up to drain for several days preparatory to washing out the ink. They were then re-pulped, bleached, and mixed with other stock. There are at least one hundred and fifty tons of this stock used in the United States per day.

As before said, it has for many years been a serious question with paper manufacturers how they shall procure sufficient suitable material to meet the continually increasing demand of the trade. European manufacturers are beginning to feel a need that the manufacturers of the United States have long felt, namely, a sufficient quantity of linen rags. In the United States the abundance and cheapness of cotton ends have prevented the use of linen to any great extent, especially as only a very small amount is manufactured in the country. Of late years the same is becoming the case in Europe. Even in flax-growing districts the high price of labour has made it more profitable for the working classes to buy the cotton goods manufactured by England, Persia, and the United States than to wear the home-spun linen, as was formerly the custom. In consequence of this, a comparatively small amount of linen is worn by the lower orders, and only the finer calicoes are made to any great extent. Moreover, the great improvement in machinery has made it possible to manufacture a better cloth from inferior material, as the paper-maker finds to his sorrow when the various processes of the mill have taken away all adventitious aid to improvement. It is in consequence of this need for more abundant and better stock that so many experiments have been made with different substances. Here let me say that it would be wise for the experimenters first to find out if others have not already gone over the ground. Many spend time and money in perfecting processes of which the utility or inutility has been proven long before by other persons.

In view of this great and growing need, it is encouraging to know with what a lavish hand nature has scattered her treasures of fibrous substances, so bountifully indeed that it would seem, with chemistry and mechanical skill aiding us, no demand could ever possibly equal the supply. In all tropical countries, both of the Eastern and Western Hemispheres, the number and variety of fibrous plants are truly wonderful. In fact, all tropical plants are fibrous to a greater or less extent. More wonderful still is the small use that has been made of these plants, when the demand for them has been yearly increasing, not only for paper-manufacturers, but for manufacturers of textile materials. In many of these countries, large quantities are yearly gathered, and after serving some local purpose are thrown away as useless.

The Fibre Exhibits.

A slight glance at the fibre plants exhibited by different countries may not be uninteresting, even if they can be used directly only for textile purposes. Indirectly they will increase the paper-maker's supply of material, for after having gone through the previous process of manufacture for a textile fabric they are available for paper stock.

To give a detailed account of the fibres of each country is unnecessary, as many of them are common to several countries, sometimes in both the Eastern and the Western Hemisphere. In Mexico, Central America, the West Indies, and the northern countries of South America, the majority of fibrous plants, if not exactly the same, belong to the same great families. Those most fruitful in fibres are the Agaves, sometimes called Aloes, a sub-tribe of the order Amyrillideæ; the Bromelias or pineapples, of the order Bromeliaceæ; the Musa, or bananas and plantains; and the Palm family, with a few varieties of the orders Liliaceæ and Malvaceæ.

The Agaves are indigenous to the American continent and islands from Virginia to Paraguay, but they flourish so abundantly in Central and South America, Mexico, and the West Indies, that it would seem an almost unlimited supply of fibre might be obtained from them. Of this family the most valuable varieties are the *Agave Americana*, *Agave Mexicana*, and *Agave Sisilana*. The *Agave Americana* grows with great abundance in all parts of tropical America, and has been introduced with success into various countries of the Old World. The fibre-producing properties of this plant are too well known to need much comment here, and it is only necessary to add that the better we become acquainted with it the more apparent its value becomes. It has long been used as a paper material, and is well adapted to the manufacture of cigarette-paper, as the fibre is very strong and burns with very little smell. Samples of this fibre were exhibited from Mexico, Brazil, Jamaica, Bermuda, and the Bahama Islands, and also from Egypt, Hindostan, and Australia, showing the wide range of country in which it may be cultivated.

The *Agave Mexicana* is indigenous to Mexico, where it is cultivated for the manufacture of pulque, a fermented liquor made from its juice. It is by many confounded with *Agave Americana*, but is an entirely distinct plant. It is especially interesting for the fibre obtained from its leaves, which is used for a variety of purposes. The State Government of Hidalgo, Mexico, exhibited a most interesting case containing specimens of this fibre and the different articles manufactured from the plant. There were ropes and cordage, fine woven goods, nets, bottles of the clear, golden-hued pulque, and other products, as gum, honey, sugar, etc. Especially deserving of mention was the paper, both on account of the quality of the goods and the cheapness of the material. This paper is remarkable for its strength; in fact it is so much esteemed for its toughness and durability that in 1830 a law was passed by the Mexican Congress requiring that all laws should be recorded upon it, and that it should be used for legal documents. Paper made from the *Agave Mexicana*, worthy of particular mention for its elasticity and strength, was also exhibited from the Belem mill of Messrs. Benfield, Braker, & Co., situated in the District of Mexico. In ancient times the native Mexicans used the leaves of this plant for paper in the same way as the Egyptians did the papyrus. The abundance and cheapness of the fibre certainly commend it to more particular attention. As the fibre is really the waste product, it could be procured at a very small cost.

The *Agave Sisilana* is the plant popularly known as Sisal hemp, the cultivation of which was introduced into Florida, where it flourished for several years. It is a native of Yucatan, Mexico, where it is called Henequen. Its cultivation and utilization are yearly increasing, and its fibre is especially valuable for ship-cables, as it possesses the property of resisting the action of sea-water. Large quantities are exported to England for this purpose. It is also used for paper material, but is not so well suited to this purpose as some others of the Agave family on account of the harshness of the fibre. Some very fine specimens of this fibre were exhibited by the State Government of Yucatan.

The whole family of Agaves are rich in fibre for paper-making, are produced in large quantities in their native countries,—sometimes in situations where nothing else will grow,—are easily gathered at small cost, and there seems no reason why they should not be utilised for the manufacture of various kinds of paper. The great trouble in their native habitats has been a want of skill in separating the fibre, as well as a proper appreciation of their real value.

Next to the Agaves may be ranked the Bromelias, or pineapples, well known for their silky fibres. The order to which these belong, Bromeliaceæ, is peculiar to tropical America, but their cultivation has been successfully introduced into several parts of the Old World. It is from one species that the beautiful textile material known in commerce as piña is manufactured. Of this family, one of the most useful varieties as a fibre-producing plant is the *Bromelia sylvestris*, known in Mexico as the istle, and in Central America as the pita. It is self-propagating, and in the latter country it increases to such an extent in the forests that it is often a serious hindrance to the passage through them. Bromelias grow also in South America and the various West India Islands, from some of which specimens were exhibited. The State Government of Oaxaca, Mexico, exhibited a variety of fibres obtained from different species, one of which was over three yards in length. Some of these were remarkable for their strength, and were produced in every degree of fineness. Like the Agaves, one great bar to their use has been the want of proper machinery for separating the fibre. Many who have tried these fibres say that they are equal to flax. They are sometimes used by the natives for the manufacture of paper for mats, cordage, ropes, etc. From all that can be learned of their properties, they seem well worthy the attention of paper-makers as a staple paper material.

The different varieties of the Musa, or bananas and plantains, which are indigenous to the continent and islands of tropical America, also furnish a good strong fibre in great abundance. In reference to these plants it must be remembered that the tree is invariably cut down when the fruit is gathered, and almost as invariably allowed to rot away. It is the fibre of the Musa family that is said to be the nearest approach to hemp or flax, and both writing and wrapping-paper of good quality were manufactured from it several

years ago in Demerara, British Guiana. Here, too, the want of proper machinery has prevented the use of the plants to any great extent. They are of rapid growth, very prolific, and easily cultivated, and the fibrous material is the part that is generally thrown away to waste. Samples of this fibre were exhibited from the British West Indian possessions.

In Central America, the northern countries of South America, and the West India islands many varieties of the palm-tree family are found. They all produce valuable fibre, which by the use of proper machinery might be available for textile purposes. Hooker says of this family, that "all palms yield textile fibres, useful especially for the manufacture of paper." From the *Attalea funifera*, it is said that nearly all the cordage used on the Amazon River is obtained. A few specimens of this fibre were exhibited from Brazil, as were also samples of different varieties of palm from some of the West India islands. These palm fibres are very valuable to the natives, and are used by them for a great variety of purposes. The species are almost innumerable, there being "over twenty-three varieties producing fruit, cordage, fibre, oil, and even spirits."

The order Malvaceæ produces most valuable fibres in both hemispheres. It is to this family that the well-known Indian hemp belongs, which grows abundantly in tropical America as well as in India. One variety, known as the Mohant tree, *Hibiscus arboreus*, produces a white fibre apparently well adapted for paper-making. It grows abundantly along the coasts of Central America. Another variety, known in the United States as the okra, is thought to be capable of producing valuable fibre under favourable circumstances. In Cuba this grows freely in all kinds of soil. Samples of this okra fibre were exhibited from Jamaica. The Society of Natural History of the City of Mexico exhibited specimens of mallow fibre, or wild silk as it is sometimes called. Several varieties grow in Mexico, and are noted for their soft and silky, yet tough fibres. They can probably be utilised for a textile material, and hence, indirectly, for paper stock.

The order Liliaceæ includes a large range of plants, many of which are cultivated only for ornament, but to it belong many valuable fibre-producing plants, among which may be named the different species of Yuccas. In America, several varieties of Yucca are found, some of them even as far north as the Missouri River, in the United States. These are known by several local names, as Adam's needles, Spanish bayonet, bears' grass, &c. No effort has ever been made in this country to utilise them for textile purposes, but it would seem well worth a trial. They grow in the poorest soils, and could be raised in many parts of the United States. In other countries, good ropes have been made from the coarser fibres, and a fine cloth resembling linen from the selected ones. The only sample of this fibre exhibited from America was from Jamaica, from which a specimen of the *Yucca aloifolia* was sent.

Of course the fibrous plants belonging to these orders are not, by any means, all that are found in America, but these have been referred to as being the most valuable. The exhibit of fibres from Jamaica was very fine, and included, in addition to those already mentioned, *Bæhmeria nivea*, or China grass, which has been successfully naturalised; *Agave Sisilana*; *Ananassa sativa* and *Bromelia penguin*, both varieties of the pineapple family; two varieties of the Musa family; the naturalised Indian plants *Calatropis gigantea*, or yercum, and *Sanseviera Zeylanica*, or bow-string hemp, of which a description is given in the East Indian Exhibit; two varieties of *Pandanaceæ*, or screw pine; palm fibres obtained from the leaf-stalks of *Caryota urens*; coir from the husk of the cocoa-nut; horsehair-like fibre from the sheaths of the *Arenga saccharifera*; and several varieties of mallow, some of which grow wild in profusion.

From the Argentine Republic, several samples of "caraguata," or "chaguar" fibre were sent. For many purposes it is said to be equal to hemp or flax. It grows in almost inexhaustible quantities, and yet has never been exported for a textile material. In the same country a species of cactus that grows very abundantly is said to furnish an excellent raw material for paper manufacture; also a kind of grass very much resembling the esparto of the Eastern world.

Among the fibres exhibited from Brazil were several specimens prepared by Mr. S. L. da C. Leite, of the Province of Minas Geraes, two of which were especially remarkable. One, the fibre of a plant belonging to the order Asclepiadaceæ, or milk-weed family, is noticeable for its admirable whiteness

and unusual tenacity. The plant grows spontaneously in the country, and has also been successfully cultivated. It has been already woven into textile fabrics, but its value as a paper material remains to be tried. It is said to resemble jute. The other was a specimen of natural paper produced from a species of fig tree, *Ficus speciosus*. The trunk leaves are soaked in water and then passed between iron rollers, and, coming out very thin, are used for writing-paper without other preparation. Mr. Leite also exhibited fibres from a reed belonging to the order Malpighiaceæ, which is peculiar to southern tropical America, and one variety of palm fibre. There were also sent from the various Brazilian Provinces several other specimens of fibre. Among these may be mentioned as belonging especially to southern tropical America, *Bertholetia excelsa*, a variety of the order Myrtaceæ; two species of *Xilopia*, known locally as white and red embira; and a third, *Xilopia sericea*, noted for its wide, long fibres, which are highly esteemed for various fabrics; *Cecropia pellata*, used for woven fabrics, and belonging to the Urticeæ; *Copaifera*, well known for its medicinal gum, but also valuable for fibre; and *Bilbergia tinctoria*, a species of Bromeliaceæ, so called from the yellow dye extracted from it. There were very few specimens of palm fibre, of which there are so many varieties in Brazil. Of these the most valuable were the *Attalea funifera*, already mentioned, and *Bactris*, also called tecun, said to be finer and more tenacious than hemp.

In many parts of tropical America fibrous plants of the Eastern Hemisphere have been naturalised, and seem to flourish as well as in their native habitats. It would seem that the great demand for textile substances might be met near home, if only advantage were taken of the materials so bountifully supplied. It might be said to American manufacturers, as was several years ago said to those of England, that "there is no want of material in every way adapted to the manufacture of paper, and paper makers would soon find it to their interest to turn their attention to some of it instead of spending their time in futile attempts to induce foreign countries to supply them with rags."

In closing the list of fibres in the exhibit from the Western Hemisphere, mention must be made of a sample of asbestos fibre, prepared by J. S. Rosenthal, of Philadelphia. This mineral is well known for its long, silky fibres, which have the power of completely resisting the action of heat. In consequence of this latter property many attempts have been made to use asbestos as a material for the manufacture of fire-proof paper, but never very successfully, on account of the difficulty of separating the foreign matters. Mr. Rosenthal has invented a method of disintegrating asbestos fibre, which seems more successful than any preceding one. The asbestos is put into wooden tanks lined with lead; it is then covered with water, and the chemicals are added. After the introduction of steam it is boiled from four to six hours. When disintegrated it is passed through a pair of rolls, the top one covered with rubber and a rubber apron running on the lower one, by means of which the water is driven from the fibre, it is then dried and manufactured into board on a machine especially constructed for the purpose. Mr. Rosenthal exhibited specimens of board made from this fibre from one-eighth to three-fourths of an inch in thickness. This board is used in packing steam-joints, covering steam-boilers, and in the manufacture of asbestos packing for steam-engines. He also exhibited some samples of paper made from the asbestos fibre, which, while not possessing sufficient strength or smoothness for writing-paper, showed great progress towards the production of a fire-proof paper.

Passing from the Western to the Eastern world, we come to countries where it would seem that centuries of occupation had scarcely left anything to be discovered, and yet here, too, there is much to be learned in regard to utilising the material so abundantly furnished.

In the Eastern Hemisphere, the plants belonging to the orders Urticeæ, Malvaceæ, Liliaceæ, and Tiliaceæ are more valuable for their fibre than in the Western Hemisphere; and some varieties of the orders Pandanaceæ, Leguminoseæ, and others, of which there are so few specimens in the New World, are valuable additions to fibrous plants. Here we find valuable specimens of the Musa and Palm-tree families. In the Egyptian exhibit especially were several specimens of fibre from the different varieties of palm. The date-palm is indigenous to Egypt, and flourishes both on the borders of the desert and in the cultivated ground. Textile fibres are obtained from the leaflets, spathe, flower-stalk, trunk, and root. There were several samples of fibre prepared

from different varieties of bananas, and also from different water-reeds growing in the numerous canals of the Nile in Lower Egypt. From one of these latter, *Cyperus dives*, called diss by the Arabs, it is said an abundance of good paper material can be obtained. The well-known cat-tail, *Typha latifolia*, also grows in great profusion, and some good specimens of its fibre were exhibited.

India has long been celebrated as a country where almost every variety of fibrous substance is produced, and an enumeration of these would be like the rehearsal of an oft-told tale. But with all that has been said and written of them, their real value as textile materials is scarcely realised even now, though of late years some have come into more general use. The exhibit of fibres from the British East India possessions contained over forty different specimens, belonging to nearly all the fibre-producing families, most of them native to the country, some naturalised. Of the order Urticeæ, or the nettle family, there were several specimens, beginning with the well-known China grass or Rhea fibre, and including several specimens native to the country. Among these may be named the Neilgherry nettle, *Urtica heterophylla;* puyba fibre, *Bœhmeria puoya*, sometimes called puya flax; and Kangra hemp, *Cannabis sativa*. Of this family of plants there is an almost unlimited supply in India, many varieties growing in great profusion along the base of the Himalaya mountains from Assam to Sutledge. A proper mode of treatment seems to be all that is necessary to render them of great value as textile and paper-making materials. Of the order Malvaceæ we find barriala from Bengal, *Sida rhomboida*, which very much resembles jute in appearance, and for some purposes is said to be superior; the "brown hemp" of Bombay, *Hibiscus cannabinus*, which is used for cordage, sackcloth, and paper; Indian mallow, *Abutilon Indicum*; and Roselle, *Hibiscus sabdariffa*. The varieties of this family differ very much in appearance, but nearly all of them are valuable for their fibre-producing qualities, and, as they grow in great abundance, are worthy of attention. From the order Liliaceæ were specimens of *Sanseviera Zeylanica*, familiarly known as bow-string hemp, which grows wild under the bushes in the jungles, is very abundant and very strong; and the *Yucca gloriosa*, Adam's needle, which has already been mentioned among American fibres. One specimen of the order Asclepiadaceæ, *Cecropis gigantea*, Yercumnar, also a jungle plant, is said to be one of the most tenacious fibres known, and is much used in Bengal and Madras for the manufacture of strong cloths, cambrics, and lawns. This fibre grows very abundantly without any special care. It is known sometimes as mudar silk cotton. Of the fibres of leguminous plants exhibited, two are especially worthy of mention,—one the Sunn hemp, *Crotalaria juncea*, said to be a valuable substitute for Russian hemp, and Jubbulpore hemp, *Crotalaria tenuifolia*. The former is a well known article of commerce, the latter only lately coming into use and employed for the manufacture of rope.

In addition to these fibres were several varieties of palm fibres, musa fibres, agaves, bromelias, screw pines, and different species of mat grass and flax; but only one of special interest to paper-makers remains to be mentioned, namely, jute, *Corchorus olitorius*, which belongs to the order Tiliaceæ, or the lime-tree family. This fibre has for many years been an article of commerce, and attention is called to it from the fact that it is capable of being used by paper-makers for a much greater variety and finer grade of paper than at present. With proper treatment a fine white fibre can be obtained from it at less cost than from the materials generally used for the manufacture of the finer grades of paper. Jute-culture has been introduced into America within the last few years. It is cultivated with great advantage in the neighbourhood of cotton-fields, as it requires the same soil and climate. It is said that when the cotton-fields are belted with jute it acts as a protection against the ravages of the caterpillar.

Many of the fibres in the Indian exhibit have never been tried as paper materials, and at present could be made use of only indirectly; the great trouble has been want of proper treatment. In order to use them to their full extent, it is necessary to disintegrate them thoroughly, and at the same time keep unimpaired the strength of the fibre and its capability of being properly bleached. This once accomplished, the want of material need never trouble the manufacturer.

One of the most complete exhibits of paper fibres made was a collection of samples prepared by the director of the Botanical Gardens at Melbourne, Victoria, Australia. In this collection sixty-nine fibrous samples were represented, some by the raw fibre, some by paper manufactured from them, and others by both the fibre and the paper. Two-thirds of the plants were natives of Australia; the other third had been naturalised. There were about forty specimens of paper.

First on the list of native Australian fibres comes a variety of the well-known order Urticeæ, or nettle family, the grass-cloth-tree of Queensland, *Pipturus propinquus*. From the bark of this tree a good fibre is obtained, which is used in the manufacture of paper. Accompanying the fibre was a sample of the paper made from it. Another variety of the order Urticeæ is the tree-nettle of Queensland, *Laportea gigas*. The fibre exhibited was prepared from the bark of this tree, which sometimes attains a height of eighty or one hundred feet. The wood of this tree is also fibrous and might be used in the manufacture of paper. The natives use the fibre obtained from the bark and roots for fishing-lines and nets. From still another variety of this family, the native nettle, *Urtica incisa*, a very good sample of paper was made. The pulp obtained from this plant is of a very fine texture, becomes a beautiful white colour when bleached, and seems well suited to the manufacture of paper. There were also samples of paper and fibre from the paper mulberry, *Broussonetia papyrifera*, and China grass, *Bœhmeria nivea*, both members of the order Urticeæ, but too well known to need further comment here.

From plants of the order Malvaceæ were several specimens. First of these may be mentioned *Langunaria Patersoni*, the cowitch-tree of Norfolk Island, which is also indigenous to Queensland. The fibre obtained from the bark is fine, strong, and glossy, and can be used in the manufacture of a good grade of paper, as the sample accompanying it showed. From the bark of the Queensland hemp, *Sida retusa*, was a sample of good, strong fibre, suitable for the manufacture of paper, twine, &c. There was also a sample from the bark of Victorian hemp, *Sida pulchella*, a small shrubby tree, growing abundantly on various rivers in Victoria. It yields a fine bast, from which a strong fibre is obtained, suitable for paper and various purposes. From the hollyhock-tree of Queensland and New South Wales, *Hibiscus splendens*, were samples both of fibre and paper. This is an ornamental shrub, or small tree, but its bark is very rich in fibre suitable for paper and other purposes. Native to the same districts is the *Hibiscus heterophyllus*, from whose bark a quantity of good fibre is obtained suitable for the manufacture of paper, as was seen from the specimens exhibited. In addition to these native fibres were several specimens of the same order from South American plants naturalised. Among these were *Abutilon venosum*, *Abutilon mollis*, *Abutilon Bedfordianum*, and *Abutilon striatum*. The bark of all of these plants yields a quantity of fine fibre, which is said to be a good paper material. From New Zealand was one specimen of the same family obtained from the bark of the ribbon-tree or lace-bark, *Plagianthus betulinus*. The bark of this tree is of a lace-like texture, and the fibre is very strong.

The largest number of Australian paper-fibre specimens was obtained from plants of the order Cyperaceæ. Many of these are familiarly known as rushes, or sedges, and are usually found near water-courses or lagoons. Among these may be mentioned the following: *Scirpus fluviatilis*, a species of club-rush of prolific growth, yielding an abundant supply of material for writing, printing, and packing-paper; a sample of this paper was also exhibited. *Carex appressa*, a sedge grass, which is also found in great abundance. The fibre is of strong, coarse texture, judging from the sample of paper, but with proper treatment it might be used for a finer grade of paper. *Cyperus lucidus*, the shining gallingall rush, which, like the plant mentioned above, grows very plentifully near water-courses, and can be readily gathered in paying quantities. It yields a large proportion of fibre of good quality, from which a strong packing-paper is made, as shown by the sample; but it might also be used for finer paper, if properly prepared. *Carex pseudo-cyperus* is often found growing with *Carex appressa*, but not in sufficient quantities to be practically available, although it is a good paper material, as the sample exhibited showed. *Gahnia psittacorum* is a kind of sword-grass, the leaves of which often attain a length of twelve feet. The paper made from this plant proves its value as a

paper material, and the quantities in which it grows and the ease with which it is gathered make it practically available. *Cyperus vaginatus* grows in large quantities in sub-alpine situations. The paper exhibited was prepared from the stems and leaves, which yield a pulp suitable for writing, printing, and packing-paper. Paper was also exhibited manufactured from the stems and leaves of another species of sword-grass, *Lepidosperma elatius*. This plant attains its greatest perfection near water-courses in sub-alpine situations, where the leaves sometimes grow to be nine feet in length. It can be obtained in large quantities, and yields a strong fibre. The coast sword-rush, *Lepidosperma gladiatum*, grows very abundantly in barren, sandy soil, all along the coast-line. This is said to furnish one of the best fibres for paper-making that is found in Australia. Samples of paper made from this fibre attracted much attention in previous Exhibitions, and were also shown in the present one. Somewhat similar to this is the *Lepidosperma flexuosa*, slender sword rush, known as mat-grass. It grows very plentifully in low-lying, swampy ground, and furnishes a strong fibre for paper-making. The fibre prepared from *Cladium radula*, black reed or cutting grass, is strong, of good quality, and suitable for a paper material. This grass grows in great abundance in rich land, and can be obtained in any quantity.

Several fibres were exhibited obtained from plants belonging to the order Myrtaceæ. One of the most singular of these plants is the *Eucalyptus obliqua* or stringy-bark tree, as it is called by the colonists. The bark of this tree yields an extraordinary amount of fibre, and as it grows to an immense height and size, the diameter being sometimes ten feet or more, an almost unlimited supply can be obtained from it. The fibre is too harsh to use alone in paper-making, as the sample showed, but is of value when mixed with other material. The same may be said of the *Eucalyptus fissilis*, the messmate of the settlers. The paper prepared from the bark of the *Melaleuca ericifolia*, swamp-tea tree, is very soft, and well suited for blotting-paper, on account of its absorbent qualities. This bark is easily obtained, and can be had in considerable quantities. These qualities belong to nearly all the varieties of Melaleucas. Paper from two other varieties, *Melaleuca genistifolia* and *Melaleuca squarosa* was also exhibited.

From the order Sterculiaceæ the following valuable fibres were exhibited: From the bark of *Sterculia acerifolia*, the flame-tree of New South Wales, both fibre and bast. The bark on this tree is fully two inches in thickness, and the bast obtained from it is of a very fine, lace-like texture. The fibre is prepared by a very simple steeping process. From *Sterculia diversifolia*, the Victorian bottle-tree, a bast is obtained in large quantities, somewhat similar to the preceeding, but coarser and darker in colour. It is prepared in the same manner, as is also the fibre obtained from the bark of *Sterculia lucida*, a tree very much resembling the first named. The fibre from all these barks is a good paper material. From the Queensland bottle-tree, *Sterculia rupestris*, a strong fibre is obtained suitable for paper-making. Another of the same family, *Commersonia Fraseri*, tie-plant, a tall-growing shrub, produces a bark that is extensively used by the settlers as a tying material. The fibre is fine, and can be obtained in large quantities. *Sterculia fœtida*, also a native of the Indian and Malayan peninsulas, produces a good, strong fibre. In addition to the native fibres belonging to this family was an African one naturalised, *Dombeya Natalensis*, which produces a fibre suitable for paper-manufacture.

Of the order Gramineæ the three following specimens were exhibited: *Ehrharta tenacissima*, a wiry grass found growing on the uplands in large quantities, and furnishing material suitable for packing and writing-paper; *Poa australis*, a rigid, erect-growing grass, found principally near streams and in marshy places, and producing a good, strong fibre; and the *Arundo conspicua*, the Phune grass of New Zealand, from the leaves and stalks of which a good paper material is obtained. Paper also was exhibited made from these grasses.

From stems of plants of the order Juncagineæ, locally called rushes, some specimens were exhibited. *Isolepus nodosa*, a rush growing plentifully on river-banks and in marshy places; *Juncus maritimus*, or sea-coast rush, as its name indicates, found along the sea-coast and salt-marshes; *Juncus vaginatus*, small sheathed-rush, and a larger variety of the same plant found along water-courses. All yield good paper material, particularly the last-named, from which a large percentage of fibre is obtained.

Belonging to the order Liliaceæ, only two native fibres were exhibited. *Dianella latifolia* grows along the banks of creeks. In favourable situations its leaves, from which the fibre is obtained, grow to a length of six feet. Its growth is abundant and the yield of fibre good. *Dianella longifolia* somewhat resembles the former, but cannot be obtained in sufficient quantities to make its use profitable. Of naturalised fibres of this order were three varieties of Yucca from America, all noticeable for their strength. From the leaves of the famous dragon-tree of Teneriffe, *Dracæna Draco*, a strong, flexible fibre was exhibited, but as this tree grows very slowly, the fibre is not of practical use. This tree is remarkable for its prodigious longevity and immense size. The dragon-tree of Orotava is supposed to be the oldest plant on the globe, and its trunk is so large that ten men joining hands can scarcely reach around it. But the most valuable fibre-plant of this order is *Phormium tenax*, or New Zealand flax, which very much resembles in appearance the Yuccas of America. This plant, as its name indicates, is a native of New Zealand, but its cultivation has been successfully introduced into Australia and a few other countries. Like its American relatives, the Yuccas already mentioned, it seems to flourish in almost any kind of soil, sandy, swampy, or rocky. Although not immediately productive, an almost unlimited supply of fibre can be obtained after a few years. A good paper material is obtained from it by a very simple process, but to keep the finer fibres uninjured a more complicated process is necessary. The fibre is very strong, and produces a paper noticeable for its whiteness. This fibre is yearly coming into more general use for paper-making and textile purposes.

From the order Amaryllideæ three specimens were exhibited,—from America, *Agave Americana* and *Fourcroya gigantea*. The third, *Doryanthes excelsa*, spear lily, is a native of East Australia, and somewhat resembles the last-mentioned plant. Its leaves are one mass of strong fibre, which furnishes a good paper material.

In addition to these were specimens belonging to various orders, nearly all the plants being natives of Australia. From the native bulrush, *Typha angustifolia*, an abundant supply of material is obtained suitable for packing-paper, and apparently capable under favourable treatment of being made into the finer grades of paper. Fibre from the Jaggery palm, *Caryota urens*, which grows on the north-east coast of Australia, as well as in India, and also from *Pandanus utilis*, or screw pine. Paper from *Juncus pauciflorus*, which yields pulp suitable for fine paper, and also from a species of swamp moss. This latter material can be had in enormous quantities, as it completely covers the surface of the lagoons, and is easily gathered. It furnishes material from which a strong packing-paper is made. From *Xerotes longifolia*, the tussock grass of the colonists, a good packing-paper is also made. This grass grows abundantly, attains considerable length, and furnishes a large percentage of fibre. From the bark of *Pimelia axiflora*, the Currijong of the natives, were specimens of both fibre and paper. This plant is peculiar to extra-tropical Australia, and grows abundantly as underwood in the forests. It has a smooth, brown bark, very tough, and yielding a large amount of fibre suitable for paper of fine quality. Allied to this, but a native of South Africa, is *Dais cotinifolia*, from which also a specimen of paper was shown. The bark yields a good paper material of fine texture and white colour. The plants of this order, Thymeleæ, all possess tenacious fibres. Of fibres naturalised from New Zealand were specimens of paper from *Pittosporum crassifolium*, and fibre from the leaves of a species of astelia. There were also fibres from two or three other naturalised plants, among which may be specially mentioned those prepared from the bark of *Sparmania Africana*. This fibre is of a fine silky texture and a beautiful silvery-white colour. It is very easily prepared and suitable for textile fabrics, and hence indirectly available for paper stock. The plant produces two crops of canes a year, and they yield a large proportion of fibre.

In addition to the fibres exhibited from Victoria, there were also some from Queenland and New South Wales, but as they very much resembled those already mentioned, it is not necessary to give a further description of them.

In the Netherlands exhibit was quite a good display of fibres from their East Indian possessions, the most of them from the Botanical Museum at Biutenzorg, in the island of Java. These included different varieties of the Musæ, Malvaceæ, Urticeæ, Tiliaceæ, Sterculiaceæ, and others, all of which

have been so fully described in the Indian and Australian exhibits that they do not need further mention here. These islands, like all this part of the world, are rich in fibrous plants, that need only to be known and properly treated to be valuable as textile materials.

The exhibit of fibres from China and Japan was small, both in number and variety. From China were several specimens of China grass and hemp, coir obtained from the outer covering of the cocoa-nut, and one specimen of pine-apple hemp. The Japanese exhibit contained only specimens of jute, musa, and China grass, and two other varieties of nettle.

Spain exhibited several fibres, two of which, although well known, are worthy of especial mention. One, esparto grass, is a native of Spain; *Musa textilis* or Manila hemp, is produced in its dependencies, the Philippine islands. Esparto grass, known botanically as *Macrochola tenacissima*, belongs to the order Gramineæ. It is found in Spain on all the lands facing and bordering the Mediterranean, where this wild grass or sedge is almost the only plant produced in the barren soil, but it gradually disappears as the fertile interior is reached. It has been long used by the natives for the manufacture of mats, baskets, &c., quite a trade being carried on in these articles. About fifteen years ago the scarcity of paper material in England induced paper-manufacturers to make the experiment of using esparto. As it proved a success, its use as paper stock has continued ever since, and now large quantities are consumed in England, France, and Belgium for this purpose. When used as paper material almost any quality can be employed, and hence only the wild grass has been manufactured into paper. Of late years the plant has been cultivated, which greatly improves it as a textile material; and it is now used in the manufacture of dress cloth, for some kinds of which it is said to be better adapted than cotton or flax. This cultivated esparto is much more valuable than the wild, which latter is rapidly decreasing in quantity from a careless method of gathering, and consequently it is yearly becoming less available for paper stock. The variety known as alfa grass, *Ligeum Spartium*, is indigenous to the opposite coast of Africa, but it is inferior in quality to the Spanish esparto.

The *Musa textilis*, from which the Manila hemp or Abaca of commerce is obtained, is the most valuable of all the musa family for its fibre-producing properties. In many respects its appearance differs entirely from other members of the musa family. The fibre is round, silky-looking, and nearly white. It is also very long; one thread exhibited measured twelve feet eight inches. It is obtained from the petioles of the leaves, and is of different degrees of fineness, the fibre from the interior being much finer than the exterior fibre. Unlike other plants of this family, the *Musa textilis* is not allowed to blossom, as the fibre is much weakened in the process. The finer fibres are used for the manufacture of the most delicate tissues, the coarser for ropes, cordage, &c. In the manufacture of strong paper this fibre is one of the best substitutes for linen that has been found. The cultivation of the plant has been successfully introduced in some of the West India islands, and in India and the islands of the Indian Ocean it is said to grow as well as in its native islands. It is now one of the leading fibres of commerce, and the plants are cultivated on at least four hundred of the Philippine islands. The whole of this Manila hemp produce is exported, the largest quantity to England, and some to the United States and Germany. Many samples of this fibre were on exhibition, not only from the Philippine islands, but also from India, Mauritius, West Indies, &c.

There were also exhibited from Spain, fibres of palm, palmetto, junco, and nea, but the two latter of these have not yet been applied to paper stock.

In the Portuguese exhibit there was quite a fine display of flax and hemp, including many varieties in different stages of preparation. The fibres are too well known to claim attention here. From the African and Indian possessions of Portugal were several fibres that are almost unknown to commerce, and others that have been in use for some time. Among these latter may be mentioned pine apple filaments from Angola and Mozambique, Africa; banana fibre from Angola, where the plants grow spontaneously and in great abundance; and fibres from the leaves of the Dendem palm-tree from Cape Verd and Mozambique, Africa, and also from India. Among the plants that belong principally, if not entirely, to Africa, three may be especially mentioned. From the ife-tree, *Sanseviera Angolensis*, a native of Angola, a

fibre is obtained which is used in the manufacture of cables and ropes. It is prepared very much in the same manner as flax. This tree belongs to the order Liliaceæ of the sub-tribe Aloineæ, which plants principally inhabit South Africa. Another fibre of tropical Africa is *Adansonia digitata*, baobab, called in Angola, whence the specimen was sent, imbondiero. This tree is remarkable for its size, and especially for the enormous thickness of the trunk, "the circumference being sometimes one hundred feet." It was formerly supposed that this tree grew very slowly and was very long lived, but the contrary is now known to be the fact. The fibre is obtained from the bark, is very strong, and is used for the manufacture of rope and also of coarse cloths, from which bags are made. From a plant of the order Asclepiadaceæ, called by the natives mundono, fibre is obtained that is used in Angola for the manufacture of a cloth which is a substitute for linen. From another plant, quiboca, a native of Angola, a fibre is obtained that very much resembles flax fibre in appearance. This plant frequently attains a height of over nine feet. The fibre is used for the manufacture of cloth and other articles. There were also several other fibres from Angola, among which those obtained from the following plants are worthy of mention: white and yellow quibori, quizunzo, quifuche, quifinei, and diolo. There were also quite a number from the Portuguese Indian possessions.

The exhibit of fibre in the British section was very large and complete, including as it did both East and West Indies and Australia, of which mention has already been made. Also included in this section was the exhibit of fibres from the Botanical Gardens in the island of Mauritius. The specimens numbered about fifty, and many of them well deserved mention. The specimens belonging to the musa family were more numerous than those of any other, and consisted of nine varieties. Some of these have already been described in other exhibits, as the musa textiles, *Musa paradisiaca*, and others; but *Strelitzia regina*, *Heliconia gigantæa*, and *Urania* (Ravenala) *Madagascariensis*, are new. *Strelitzia regina* is a native of South Africa, and *Heliconia gigantæa* of tropical America. *Ravenala Madagascariensis* is said to be the finest species of this family. Its popular name of travellers' tree is due to the reservoir of the leaf-sheaths, in which a limpid and fresh water collects, which may be obtained by pressing the base of the petiole. The pulpy aril of the seed, remarkable for its magnificent blue colour, yields an abundant volatile oil. Like all of this family, the petioles of the leaves of these plants are formed of very tenacious fibres.

From the order Sterculiaceæ, in which so many of the Australian fibre plants were included, were several species, of which the following may be especially mentioned. Theobroma cacao is peculiar to America, but is cultivated in Asia and Africa. It is especially valuable for its seeds, from which are obtained a fixed and solid oil, called cacao butter, and other valuable products. There were also fibres from *Pterospermum acerifolium*, *Guazuma ulmifolia*, and *Melochia liliacefolia*, the last named belonging to South Africa.

Of palm fibres there were specimens from *Livistona mauritiana*, *Latania aurea*, *Sagus ruffia*, and *Sagus saccherifera*, the last two familiarly known as sago palms. There were four specimens of the genus Sanseviera, order Liliaceæ, *S. zebrina*, *S. Zeylanica*, *S. latifolia*, and *S. cylindrica*, all of which abound in extremely fine textile fibres. Of the order Pandaneæ there was only one specimen, *Pandanus utilis*. This is somewhat singular, as the number of species of this order in Mauritius, where they are called vacaos, is a remarkable botanical feature of the island. Of the genus Ficus, familiarly known as figs, there were four samples, all of which produce tenacious fibres similar to the Urticeæ. From the order Aroideæ were three specimens, *Colocasia antiquorum*, and two varieties of Caladium. The first named is a native of India, but from time immemorial has been cultivated by the Egyptians, and has spread all over the tropics. The varieties of Colocasia and Caladium are cultivated as ornamental plants for the size and elegance of the leaves. Of the genus Dracæna were two varieties, one belonging specially to Mauritius. Of the order Malvaceæ four varieties, and of Agaves from America three varieties, *A. Americana*, *A. Mexicanea*, and *Fourcroya gigantea*.

Of miscellaneous plants the following may be mentioned: *Cordia myxa*, an Asiatic tree cultivated in very ancient times by the Egyptians for its medicinal

properties; *Alpinia magnifica*, a plant which grows very abundantly in tropical Africa; *Ixora corylifolia*, of the order Rubiaceæ; and *Carludovica palmata*. This last-named plant belongs to the order Cyclantheæ, which grows exclusively in tropical America. *Carludovica* flourishes in the damp forests of Ecuador, Peru, and the United States of Colombia, South America. From the leaves a much-valued straw is obtained, which is used in the manufacture of Guayaquil or Panama hats. Many of these fibres have never been used as paper materials, but it would seem that some of them are worthy of a trial, especially those that are already extensively cultivated for other purposes. There was also a specimen of the well-known fibre plant *Bœhmeria nivea*, and also of a species of mulberry, *Morus tartarica*.

One exhibit of paper stock from England proper is deserving of mention. This was a case from the Ford Works Company, containing samples of esparto, rice-straw, maize, New Zealand flax, refuse sugar-cane, and bamboo. The samples were presented in different stages of preparation,—first in the natural state, then brown stock, then bleached half-stuff, and finally in paper. The samples of paper were all clean and of good colour. Among these samples those of the bamboo were especially noticeable. This has been used as a paper material for time out of mind by the Chinese and Japanese, but has never been utilised to any great extent by European manufacturers. If this could be done it would furnish an almost unlimited supply of material. The *Bambusa vulgaris* is more generally distributed than any other variety, being found in abundance in both hemispheres. In India it grows in such profusion that it frequently forms impenetrable jungles, and in South America and the West Indies its cultivation has been successfully introduced. It is said that there are over one hundred and seventy varieties of bamboo, many of them familiarly known as canes, and wherever heat and moisture exist some species is generally found. In the United States some varieties are found in great abundance in what are locally known as cane-brakes, which are most frequent in the Southern States along river-banks and in swampy ground. Pulp manufactured from these canes has been in use for several years, three separate companies having been formed specially for its manufacture.

In the Belgian exhibit was a case of assorted paper stock sent by John Pfeffer. This consisted of eighty-four different grades, ranging from the finest white linen rags to samples of waste made up of old iron, broken glass, and old shoes. This exhibit showed a very good classification of paper stock. The exhibitor also claims that he is able to disinfect the stock by means of chemicals, so as to prevent any smell or danger from contagious diseases.

The Paper Exhibits.

It is to be regretted that the display of paper from the United States was not more complete. But very few of the numerous and extensive mills of the country were represented, and these were almost all Eastern establishments. This shows a very reprehensible indifference on the part of our manufacturers in regard to their present reputation and future business interest. However, the display, though small in quantity, was excellent in quality; in fact, the superiority of the leading exhibits was so marked that is seemed to leave nothing to be desired, and the excellence was so uniform that it is almost impossible to make any comparative report on standard American papers.

The exhibit of bond, ledger, and blank-book papers, of superfine linen for note, letter, and cap-papers, some of the latter in many tints, was superb, and not equalled by similar exhibits from other countries. The chromo, steel-plate, wood-cut, and book papers exhibited were very fine, and all that could be desired. The amount of blotting-paper displayed was small, but the quality was of the highest order. Of news-paper proper there was no exhibit, which is especially to be regretted, as the United States is a very large producer and consumer of this grade of paper. Likewise, there was no exhibit of Manila paper proper, but the two or three exhibits of building-paper made from Manila stock were very good. Wrapping-paper was scarcely represented at all, and the display of card-board, Bristol-board, book-binders' and box-makers' board was very meagre, but of good quality. The two exhibits of tissue-paper were also of very good quality. Among the exhibits the following may be especially mentioned:

PORTER AND BAINBRIDGE, New York, N. Y.

A large assortment of card stock of every description, and also a large variety of papers and envelopes of both foreign and domestic make.

RHODE ISLAND CARD-BOARD COMPANY, Pawtucket, R. I.

A variety of differently coloured card-board, which was of good quality, possessing both hardness and elasticity.

W. O. DAVEY, Jersey City, N. J.

A lot of tar or binders' boards of excellent quality, the only display of the kind brought to my notice.

ZENAS CRANE, JR., Dalton, Mass.

White and tinted Bristol-boards of very good quality.

THE ANDROSCOGGIN PULP COMPANY, Portland, Me.

A good sample of wood-pulp, and also boxes made from the wood-pulp board. The boxes were not entered for competition, but were good of the kind.

CASE BROTHERS, South Manchester, Conn.

Press-boards, which were hard, strong, and of excellent quality, with the one exception that they were lumpy. A little more care in the preparation of the stock would have produced a No. 1 board.

MOUNT HOLLY PAPER COMPANY, Mount Holly Springs, Pa.

A small but very creditable display of ruled papers.

OWEN PAPER COMPANY, Housatonic, Mass.

One of the largest displays of writing-paper in the Exhibition, including a large line of their foreign correspondence, fancy rep, and drawing-paper. The papers were excellent in every point except sizing, which might have been better.

PARSONS PAPER COMPANY, Holyoke, Mass.

A good display of coloured writing and envelope paper, which looked very well.

CRANE BROTHERS, Westfield, Mass.

Bank-ledger and record paper of excellent quality; also Japanese paper baskets and paper belting. These baskets are very good of their kind, and the belting can be used in a dry place. It is cheap and well made, and probably will do all that is claimed for it.

MEGARGEE BROTHERS, Philadelphia, Pa.

A good engine-sized paper, second quality, envelope-papers in all colours and shades, granite cover-papers, plate-papers, and assorted coloured mediums.

JESSUP and MOORE, Philadelphia, Pa.

A very good line of copper-plate, lithograph, wood-cut, and super-calendered book-papers, all of which contained wood cellulose or chemically prepared wood-pulp. They also exhibited printed samples of these papers, which looked very fine.

NASHUA CARD AND GLAZED PAPER COMPANY, Nashua, N. H.

Cut cards, a small lot of card-board stock, in sheets, and four or five rolls in coloured stock. They also sent in a fine line of cardboards for examination but as the goods were not on exhibition they could not be passed upon.

HURLBUT PAPER COMPANY, South Lee, Mass.

Several reams of flat and folded papers, very plain looking but of good quality.

WHITING PAPER COMPANY, Holyoke, Mass.

The finest paper display in the Exhibition. They exhibited about one hundred and seventy-five different styles of paper, put up in two hundred different styles of wrappers. Included in their display was a ream of the largest sheets of animal-sized, loft-dried paper ever made. It was six by eighteen feet, and from one ream of this paper five hundred thousand sheets of note-paper could be made.

JOSEPH PARKER, SON, & Co., New Haven.

About one hundred reams of their Treasury blotting-papers. These papers were the best of their kind on exhibition. They were tough, possessed the necessary absorbing qualities in a high degree, and were of the first quality in every respect.

SEYMOUR PAPER COMPANY, Windsor Locks, Conn.

A large variety of cover and other coloured papers, all of good quality.

BYRON WESTON, Dalton, Mass.

An elegant exhibit of first-class ledger-paper. There was no better paper in the Exhibition as to texture, strength, and finish.

CRANE & Co., Dalton, Mass.

Bank-note, bond, and parchment papers of excellent quality, strong, flexible, and well sized.

SOUTHWORTH COMPANY, Mittineaque, Mass.

A beautiful display of clean and well-made paper, consisting of bank-ledger and different kinds of writing papers. They were the cleanest and best-woven papers in the Exhibition.

L. L. BROWN PAPER COMPANY, South Adams, Mass.

A fine exhibit of ledger-papers. They were not as well-woven as some others, though exceedingly well sized.

H. V. BUTLER, JR., & Co., Paterson, N. J.

A variety of papers, among which their silk copying-paper was noticed as being very fine. They also exhibited in rolls animal-sized paper, which enables map publishers and others to use large sheets of paper without pasting them together.

TILESTON & HOLLINGSWORTH, Boston, Mass.

A fine line of chromo, steel-plate, wood-cut, and calendered plate-papers, the finest of their kind on exhibition.

CHAPIN & GOULD, Springfield, Mass., and CARSON & BROWN PAPER COMPANY, Dalton, Mass.

A creditable display of their lines of goods, but no specialties.

DENNISON & Co., Boston, Mass., and New York, N. Y.

Among other articles, a very fine tissue paper, called Excelsior coloured tissue.

In addition to these, the Haldeman Paper Company, Lockland, Ohio, exhibited a large line of roofing-papers; George P. Tangeman & Co., Hamilton,

Ohio, four rolls of carpet paper; T. Seymour Scott & Bro., Philadelphia, carpet and building paper; Joseph Stelwagon & Son, Philadelphia, roofing and felt papers; James Guie & Sons, Downing-town, Pennsylvania, exhibited paper-wrappers of excellent quality.

The exhibits from foreign countries were not as full as was desirable. England was very poorly represented, there being only three exhibits made. One of these—that of Robert Fletcher & Son—contained the finest coloured tissue in the Exhibition.

The display from France was also small. She excelled, however, in photograph-papers and cheap engine-sized writing-papers.

The display from Germany consisted chiefly of a low grade of paper made from wood-pulp, both chemically and mechanically prepared.

The Austrian exhibit was limited in quantity. It contained but one exhibit of writing-paper; the display of cigarette-paper was very good.

The best display of any foreign nation was that of Spain. Including a variety of paper, it excelled especially in cigarette-papers.

From Russia there was a good exhibit, especially of writing-paper, which was strong and well made.

Italy displayed some good samples of hand-made paper. It possessed strength, but lacked finish, and did not indicate any great degree of progress.

Sweden displayed the finest lot of wrapping-paper in the Exhibition, and also some very good samples of wood-pulp, both chemically and mechanically prepared.

The Mexican exhibit contained some very good paper made from native fibres. As mentioned above, that made from Agave fibre was the strongest paper in the Exhibition. Egypt also exhibited specimens of paper made from native fibres, which were of very fair quality.

The exhibit of papers both from China and Japan was very creditable. Their papers, however, are adapted to their own peculiar uses, and are so different from those of Europe that they can scarcely be compared with them.

There were also exhibits of paper from some other countries, but these were not of sufficient superiority to merit particular mention.

In concluding this report I desire to say that I have hardly done more than to outline the paper and paper-making exhibits, with the classes of fibres which can be utilised directly or indirectly in the production of paper. The field is wide and affords much room for study and investigation, which it is to be hoped will be given to it by men who are devoted to these interests, and I shall be glad if, in this review of the exhibits, I have been able to direct more earnest attention to a subject of so great importance.

GENERAL REPORT

ON

GROUP XVIII.

RAILWAY PLANT, ROLLING STOCK, AND APPARATUS; ROAD ENGINES.

JUDGES.

American.	*Foreign.*
FELICIAN SLATAPER, Chief Engineer, Penna. Co., Pittsburg, Pa.	Captain DOUGLAS GALTON, C.B., R.E., (President,) Great Britain.
T. A. MORRIS, Indianapolis, Ind.	ERNST PONTZEN, C.E., Austria.
ROBERT E. RICKER, Elizabeth, N. J.	E. SCHARR, C.E., Belgium.

GENERAL REPORT.

RAILWAY PLANT, ROLLING STOCK, AND APPARATUS; ROAD ENGINES.

Continuous Railway Brakes.

The want of a good continuous brake was felt almost simultaneously with the invention of locomotives. Roberts took out the English patent No. 6258 on April 13, 1832. George Stephenson, the father of the railway, also appreciated this need, and took out the English patent No. 6484, October 7, 1833. Twenty years ago experiments were made on the New York and New Haven, Michigan Central, Old Colony, and other roads, and some thirty or forty American patents were granted for various devices. None were introduced to any extent up to the year 1870, excepting Creamer's spring-brake and Loughridge's chain-brake. The former, a device only intended for emergencies, was so arranged that the brakesman could wind up by hand a spring-coil on each car, the clips to which were attached to the bell-cord. When the engineer saw danger ahead he pulled the bell-cord from the locomotive, which released the springs and applied the brakes. The Loughridge brake was operated by a chain running the length of the train, connected between the cars by a simple hook, having a loop under each car. By pulling this chain the tendency to straighten the loop caused (by a simple arrangement of levers and pulleys) the brakes to act against the wheel with a force depending upon the power applied to the chain. This chain was drawn up by a windlass which was caused to revolve by pressing a friction-wheel, fastened upon it, against the flange of the driving-wheel. A device was used with the intention of causing the friction-wheel to slip when the brakes were fully applied. This friction-wheel frequently broke the chain, and, to overcome this difficulty, Loughridge used a long cylinder, the piston of which is attached to the end of the chain, and the chain is drawn up by ordinary steam-pressure from the boiler of the locomotive.

Much progress has been made within the past few years in the devices to secure a perfect control of trains by brakes. After a train of cars has been under motion, a momentum is stored up proportionate to headway made and speed of train. This momentum has to be destroyed almost instantly, and can only be destroyed with safety by the use of friction appliances, causing the whole weight of the train to slide, or partly slide, upon the rails. As the result is seriously affected by the loss of time, we have the necessity of instantaneous action forced upon us. To instantly utilise the weight of the train in destroying its momentum requires the transmission of a force from one point to ten or twelve different bodies, which have a limited motion in every direction. The force distributed upon the wheels of an ordinary American car amounts to not less than twelve tons, or for a train of ten cars and an engine a force of not less than two hundred tons must be instantly distributed among the wheels of the train, according to the weight with which each wheel bears upon the rail. A further necessity is that this force must yield to every irregularity in the motion of the running gear.

The Westinghouse brake as now manufactured can hardly be considered the same device as when first brought out in 1869. In its original construction it consisted of two essential parts, a power-generating apparatus and a system for transmitting this power to all of the wheels of a train when wanted. The first part consisted of a direct-acting air-compressing pump attached to the engine, and driven by steam from the boiler, and a main reservoir also upon the engine. This pump maintained a steady pressure of about eighty pounds per square inch in the reservoir, as indicated by a gauge in the cab. The second part consisted of a brake-cylinder with piston arranged to press against the brake-levers, and a length of pipe with a branch leading to this cylinder.

These pipes were united from car to car by flexible hose connections, furnished with couplings containing valves so arranged that when the couplings were united there would be an open communication from the engine back along the train to the coupling at the rear end, which was closed by its valve. On the engine was a three-way cock having one connection to the main reservoir, and one to the brake-pipe extending the length of the train. The engine-driver by simply turning the handle of this cock could admit air from the main reservoir to the brake-pipe, and thus cause all the pistons to be thrust forward, bringing the blocks against the wheels with any desired force. If the train broke in two, the couplings, being held together by springs, would separate without injury, and the valves would close and the brakes remain on. The brakes were released by again turning the handle of the three-way cock so as to allow the air in the cylinders and brake-pipe to escape, when strong springs pushed the pistons back.

This system partly met the requirements, as will be seen:

1st. The power was stored on the engine, ready for use where most needed, and was an elastic substance.

2nd. Each car had the cylinder and connections so arranged that an equal pressure would do a like amount of work in all cases.

3rd. The force, being an elastic one, insured an equal proportionate pressure against all of the wheels.

4th. The power was not affected by the oscillation of the cars, as the connections were flexible and were unaltered in capacity or length.

5th. Sufficient power was insured to cause the whole train to slide upon the rails if desired.

The principal points of weakness in this brake were as follows:—The failure of a pipe rendered the brake temporarily useless. The breaking in two of the train rendered the brake inoperative on the rear portion. The time required for the air to flow back through the long tubes under the cars prevented the instantaneous application of the brake.

Experience demonstrated that several contingencies might arise: (1) The engineer might observe an obstruction on the track, a broken rail, &c. (2) The train attendants might discover a car on fire or off the rails. (3) The brake-power might fail. (4) The train might break in two. It was also found that the saving of even a second in the application of the brakes would in many instances prevent or greatly lessen damages. The contingencies made it necessary that the brakes could be instantly and fully applied by the driver, conductor, or any other employé, from any part of the train, and that the brakes should be automatically applied by a sudden failure of the brake-power, or by the breaking in two of the train.

The Westinghouse automatic brake, as now in use, it is claimed fully meets every requirement that can possibly arise, and is the result of a long series of careful experiments. The same air-compressing apparatus, main reservoir, three-way cock, brake-pipe, and cylinders are used with the automatic as with the first system. In addition, the tender and each car have a small reservoir and triple valve located near the brake-cylinder. The connection from the main brake-pipe is made to one opening of the triple valve, and from a second opening a pipe leads to the brake-cylinder, while a third opening connects with the auxiliary reservoir. The connections between the cars have malleable iron couplings without valves, and cocks are put in the pipe at each end of every vehicle; all of these cocks, except the one at the rear of the train, being kept open when the train is connected. When the brakes are off, a constant pressure of about eighty pounds per square inch is maintained in the main reservoir, brake-pipe, triple valves, and all auxiliary reservoirs throughout the train. The brakes are applied by causing a decrease of pressure in the brake-pipe, which shifts the triple valve on each car, so as to close the port to the brake-pipe, and open a port which permits air to flow from the auxiliary reservoir direct to the brake-cylinder, when the piston actuates the brake-levers as in the first system. The engineer causes this decrease by simply turning the handle of the three-way cock in the cab so as to permit a portion of the air to escape from the pipe. A valve is placed in the pipe under each car connected to a cord running through the interior of the car, and any person in the train by pulling this cord can open the valve, allow the pressure to escape from the pipe, and thus apply the brakes to the whole train. If the

train breaks in two the couplings part, and the air escapes from the pipes on both detached portions, applying the brakes to both instantly. The derailment of the train would cause their application in the same manner, as a train always breaks in two when a portion leaves the track. The bursting of a hose or pipe would also discharge the air and apply the brakes. To release the brakes the engineer turns the three-way cock, so as to allow the pressure in the main reservoir on the locomotive to flow back through the pipe, when the triple valves shift to their original position, opening a port from the brake-pipe to each auxiliary reservoir, and giving it a fresh supply of air, closing the connection between the auxiliary reservoir and brake-cylinder, and opening a port which allows the air in the brake-cylinder to escape and the piston to be pushed back by springs.

In this system the air is stored in the auxiliary reservoirs, close to the brake-cylinders, and no appreciable time is required for its passage into the cylinders, hence no time is lost by the air having to flow back through long tubes, the transmission of the power being effected when the brakes are not in use. A reduction of only fifteen pounds in the pressure in the brake-pipe is sufficient to shift the triple valves and apply the brakes, and this reduction can be made in less than one second. A slight reduction of pressure applies the brakes slightly, and they may be applied with any desired force up to the maximum.

The Henderson hydraulic brake, as its name implies, is worked by hydraulic pressure, and is very simple in its construction and application.

The Goodale steam-brake is worked somewhat like the air-brake, except that steam is used instead of air.

The Smith vacuum-brake is worked by means of an ejector on the engine, which exhausts the air from two collapsible rubber cylinders under each car, through pipes running the length of the train. The atmospheric pressure collapses these cylinders and actuates the brake-levers attached to one head of same. This arrangement is very simple.

Chilled Cast Wheels for Railways.

By Felician Slataper.

According to Wood's *Practical Treatise on Railroads*, the first railways were laid in England between 1602 and 1649, the precise date being unknown. The first rails were of wood, on which were run waggons having wheels of wood, for carrying coal from the mines to vessels. About 1738 cast-iron rails were first used, and about 1753 cast-iron wheels began to be substituted for those made of wood. The first cast-iron wheels were not chilled; they were cast in one piece, the hub being connected with the rim by straight spokes. The tread, not being hardened, soon wore out, and to remedy this the wheels were cast in a "chill,"—or, as it was then defined, "case-hardened."

The property which cast-iron possesses, of becoming hard or chilling when run in a molten state against cold iron, must have been known at a very early date to those engaged in the smelting of iron. Before chilled wheels were made chilled iron had been used in parts of ploughs, the face of forge-hammers, punches for punching holes in heated tires for waggon-wheels, and for other purposes. Wheels with cast-iron hubs and rims, and flat wrought-iron spokes cast into the hubs and rims, were used on the turnpike at Mauch Chunk, Pennsylvania, in conveying coal to the river, in 1826: whether they were chilled or not is not mentioned (see *Journal of the Franklin Institute*, vol. vi., page 360). Wheels of this form were used at this point, with chilled rims, on the completion of the railroad to the river. In vol. viii., pages 281 and 352, of the same journal, are extracts from Wood's *Treatise on Railroads*, which show that the wheels first used under locomotives and cars in England were made of common cast-iron; that they afterwards had wrought tires shrunk on them; that the durability was 5 to 1 in favour of the wrought-iron tire; and that prior to 1831 wheels with chilled treads were in general use in England. Mr. Wood thus describes "cast-iron wheels case-hardened": "A complete remedy was, however, effected "a few years ago" (for cast-iron wheels, not chilled) "by what is called 'case-"hardening' the rim of the wheels. This is done by placing a massive ring "of cast-iron around the mould for forming the casting of the wheel, and run-"ning the metal which forms the exterior surface of the rim of the wheel

" against the cold, cylindrical piece of iron. The rapid abstraction of heat by " the cold iron produces such a degree of compactness and hardness to the " surface of the wheel in contact with the cold iron, that the file has no effect " upon it, and this hardness effectually prevents the action of the rail from " wearing the wheel into grooves." The great difficulty attending the making of chilled wheels was here encountered, which Mr. Wood thus describes: " The " operation of case-hardening was at first attended with great difficulty; the " rapidity with which the cold iron caused the rim to cool produced an unequal " contraction of the metal, in all the several parts of the wheel, and made them " frequently fly in pieces. The rim, being first cooled, would not yield to the " contraction of the spokes in cooling; and therefore, when the spokes cooled, " if the contraction did not cause them to separate immediately, it left such a " tension upon them that the shock they received when brought into use soon " made them crack, and thus rendered the wheel useless. The plan now mostly " used, where the wheel is formed of cast-iron, is to cast the nave in two pieces, " two hoops of wrought-iron being laid around the nave to secure it. The " universal adoption of case-hardened wheels on all the principal railways, " in preference to the common wheels, is the best evidence of their superiority. " It will be subsequently seen that the cast-iron wheels of the Killingsworth " engine had been hooped with wrought tires."

It is not definitely known at what date the first cast chilled wheels were made, but in 1816 a patent was granted to Losh and Stevenson for a wheel with a solid cast-iron hub, connected by wrought-iron spokes to a cast-iron rim "case-hardened" on the tread.

The cast-iron wheels described, even with the hub divided into two sections, to partially relieve the spokes from the tension produced by the unequal contraction in cooling, were not strong, and did not prove very satisfactory in service. They were, therefore, soon supplanted by wheels with cast-iron centres and wrought-iron rims or tires, and such wheels were in quite general use in Great Britain when railways were commenced in this country, about 1830.

Probably the first chilled wheels used on a railroad in this country were made by Jonathan Bonney, at Savage Factory, Maryland. They were of the ordinary flat-spoke pattern, and were used on the Baltimore & Ohio Railroad; this fact is substantiated by Mr. William Belt, now a resident of Wilmington, Delaware, who worked for Mr. Bonney, in Maryland, in 1829, and removed with him to Wilmington in 1830. Wheels of this form were made by Jonathan Bonney & Co. in Wilmington, in 1833 or early in 1834; they were used on the railroads leading out of Philadelphia, and on the New Castle & Frenchtown Railroad. About the same time, wheels of the same form, but with a wrought-iron ring imbedded in the tread, were made by Mr. Ross Winans, at Baltimore, under a patent granted to Phineas Davis, whose claim was " the use of a ring " or hoop of wrought-iron, to be laid and cast within the body of a railroad-" wheel, in such manner as to operate as an internal chill, to cool more rapidly, " and consequently to harden the part under the curve or cone near the flange." Spoke-wheels were generally made with 12 spokes when the diameter was 33 inches, the spokes at the hub about two inches less in width than the length of the hub, and at the tread nearly the width of the latter. To prevent the arms or spokes from breaking by the shrinking of the bub, which remained hot longer than the rim, it was necessary to separate the hub longitudinally in three places, as annealing or cooling in hot sand was not then practised by iron-founders, except in a limited way. The openings or slots in the hub were filled with iron keys, or with some kind of metal, like type-metal, that would expand in cooling, and a strong wrought-iron band was shrunk on each side of the hub. The wheel was then bored and pressed on the axle, the wrought-iron band receiving the strain produced by forcing the axle on to the hub, and of the key then used, to prevent the wheel from becoming loose on the axle. These chilled wheels were in general use here until the great increase of our railways, the substitution of the heavy T-rail for the light, flat bar-rail, and the greater weight and speed of our trains, made a stronger and more durable wheel necessary for economy and safety.

Many attempts were made to cast chilled wheels with a plate or plates connecting the hub with the rim, instead of spokes, and the records of the United States Patent Office show that from 1830 to 1848 there were forty-six patents granted relating to railroad-wheels, most of which were for forms of patterns,

or for some device for overcoming the strain or tension produced by the unequal contraction in cooling, as before described. Some good wheels were made of the plate patterns; but all, if well chilled, had more or less strain on the plate after cooling, which rendered them very liable to break in service, and most of them broke before they were worn out.

In 1833, John Elgar, of Baltimore, patented a wheel, with a chilled rim, cast-iron hub, and two wrought-iron plates, convex on the outside, either curved or conical, the plates rivetted to the hub and rim. This was the first plate-wheel made. It was expensive, and did not supersede the spoke-wheel.

Many others obtained patents for wheels of different kinds, some with wooden spokes and felloes, cast-iron hubs, and wrought-iron tires; some of cast-iron with three wrought-iron hoops forming the tread, and others having cast centre, chilled flange, and wrought-iron tread, &c. The spoke-wheels with chilled treads were, however, used almost universally for truck-wheels for engines, tenders, and cars, up to 1838. Truck-wheels for engines were generally made with flanges on one or both sides of the arms or spokes, and on the inside of the tread between them. Spoke-wheels were also devised and patented, with the spokes of divers forms and arranged in various ways, none of which were any improvement on the ordinary spoke-wheel, excepting probably that of Henry R. Dunham, patented February 15, 1838, which was for a series of spokes, the hub being split longitudinally, to allow for contraction, and a hollow rim. This wheel possessed an advantage over the spoke-wheel,—a hollow tread,—but it was not used to any great extent, on account of the introduction of the double-plate wheel about the same time. Many spoke-wheels made of iron, possessing the proper degree of tenacity and chilling properties, qualities not generally combined, proved satisfactory. The absence of these properties in the iron used, and the want of skill on the part of the manufacturers, caused many to break, and to wear rapidly. Spoke-wheels, if not made of suitable iron, and selected with great care, are liable to break in the tread between the spokes, especially when not chilled deep,—and but few were chilled as deep as the plate-wheels now are; they would wear flat opposite to the spokes.

The desire to remedy these inherent defects in the spoke-wheel led to the invention of the plate-wheel. All attempts in this direction, however, prior to 1838, were unsuccessful, because proper provision was not made in the form of the wheel for the unequal contraction of the different parts, and they consequently broke or split in cooling. The practice of pitting, or gradual cooling, had not then been introduced amoug wheel-makers.

Early in 1838, wheels were made by Truscott, Wolf, & Dougherty; and a patent was granted to them on March 17 of that year for a wheel cast in one piece with a solid hub, connected with the rim by two curved plates, running parallel to each other, or nearly so, the outside plate convex, and the inside plate concave. This wheel was not a success, and did not come into general use.

About the same time, George D. Lobdell devised and patented, on March 17, 1838, the double convex plate-wheel, known among railroad men as the Bush & Lobdell wheel, which was used for several years, almost exclusively, under engines, tenders, and passenger-cars, and also extensively under freight and other cars. The wheel was cast in one piece, the plates or discs were convex on the outside, the hub divided transversely, to prevent the cracking of the plates in cooling; the contraction of the rim, which took place first, had a tendency to open the plates, thus preventing them from being on a strain, and allowing them to yield when the hub cooled; the slot being filled with type-metal before being drawn on the axle. This form of wheel was very strong, admitted of a very perfect and uniform chill, and was free from the objection and defects of the spoke-wheel. Many of them made very great mileage,—one that was on exhibition at the International Exhibition having been in use for twenty-five years on the New York & Erie Railroad, others on the Philadelphia, Wilmington, & Baltimore Railroad for twenty and twenty-two years. These wheels were not pitted or cooled in sand, or annealed by any other process. The strain or tendency to crack was compensated for by the curved plates.

In 1844, E. A. Lester obtained a patent for a single-plate wheel, having a

waved plate. This form of wheel has never been successful on steam roads. It has been, and is now, extensively used under horse-cars, on account of its lightness.

In 1845, George W. Eddy, of Waterford, New York, patented a wheel with the inside plate convex, the other undulating or waved, and a solid or undivided hub, These wheels did not require pitting or annealing, the plates yielding as the parts contracted, and when made of good material were strong, and if properly chilled wore well and gave good satisfaction. Other wheels, both single and double plate, with waved and corrugated plates, some with brackets on one, and some on both sides, were patented by several parties, but all constructed so that the plates would bend or yield to allow for the unequal contraction. These proved unsatisfactory, and therefore did not come into general use.

On April 17, 1847, Mr. Sizer patented a wheel, the hub connected with the rim by two curved plates, both plates concave on the outside. The manufacture of this wheel led to the great patent suit of William V. Many *vs.* Sizer, which was decided in favour of Mr. Many, who had become the owner of the patent of Truscott, Wolf, & Dougherty, and which sustained the claim that all wheels made with curved plates and in one piece were infringements of that patent.

In May, 1847, Anson Atwood patented a wheel, described in his claim as follows: "Connecting the rim of the wheel cast in one piece, with a solid hub, by the combination of a ring made of radial waves, in combination with the dished flange or flanges of the hub, which forms a rim concentric with the rim of the wheel, substantially as described, whereby the several parts can yield to unequal contraction in all directions, without serious strain of the metal, as described." These wheels were used to some extent, principally for freight cars, and were generally pitted or covered in sand. They were subject to the objection common to all wheels which have plates with corrugations extending to the rim and uniting with it at points equally distant from the flange or rail line. This causes the chill to be of unequal depth and hardness at different points of the same section of the tread, occasioning them to wear more rapidly in one place than in another.

Prior to 1847 or 1848, the pitting or gradual cooling of wheels by covering them in sand, or placing them in a heated oven, was not practised; consequently all plate-wheels had to be made with the plates curved, so that they would yield and accommodate the different parts to the unequal contraction. The process of cooling is by most wheel-makers termed annealing, which is a misnomer. To anneal is to "heat nearly to fluidity," &c. A degree of heat much below fluidity applied to a wheel will soften the chill so as to render it unfit for use. The necessity for the process is this: the tread and the parts of the plate or plates farthest from the hub cool most rapidly and shrink first, consequently the shrinking of the hub and parts of the plate or plates next to it, which takes place afterwards, produces a strain, which ruptures the plates, and causes the wheel to break. To prevent this, various expedients have been resorted to. Some passed a current of steam or water through the hole in the hub; some placed the wheels in a pit on a bed of sawdust or fine charcoal, and put sawdust or charcoal between them on the plate; and others put them in pits and passed a current of air through the hole in the hub. This last process was used by Bush & Lobdell, in 1847 or 1848. At the same time dry sand or ashes were applied to the rim and plate, but this was abandoned, because it was found that when the wheels were removed from the pit the rims were hotter than the hubs. They then tried covering them in hot dry ashes, and afterwards in hot sand, which was found to answer equally well. This process was also used about the same time by Mr. Washburn and others, and it is now used by almost all wheel-makers. The effect of this process is as follows: Iron being a good conductor of heat, and sand a poor conductor, the extra heat which is in the hub and other parts when the wheel is covered is imparted to the colder parts; and as the sand prevents a rapid cooling, all parts cool, and consequently shrink, alike, thus relieving the wheel from any strain that would result from one part cooling and shrinking before another.

In 1848, Asa Whitney, of Philadelphia, invented a process of annealing or cooling wheels by placing them in an oven and heating them, then allowing them to cool slowly. The first wheels cast by him, and so annealed or cooled,

had a single corrugated plate. In 1854 he made the plate straight, or nearly so, with brackets on the inside, connecting the hub and rim. Of this form the firm of A. Whitney & Sons have cast and continue to cast large numbers. Mr. Whitney's first experiments, like those of others at that time, were made by forms of pattern which would yield to the unequal contraction in cooling, and thus neutralise the strain; and he patented several forms of wheel for this purpose, but none of them proved successful. The experiments in this direction, however, led to the process of slow cooling, or annealing, for which a patent was granted to him, April 25, 1848. The patent may be briefly described as follows:

"A process for annealing and cooling chilled cast-iron car-wheels, consisting " in removing the wheels from the moulds before they have cooled sufficiently " to produce any inherent strain on any part, and immediately depositing them " in a previously-heated furnace or chamber, and raising the temperature to a " proper point, below fusion, and then allowing them to cool so slowly that all " the parts of each wheel shall cool and shrink simultaneously." This process was a great discovery in wheel-making, and, although for some years afterwards others were experimenting in and patenting forms of pattern to overcome the unequal contraction in cooling, the great advantages of the slow cooling and annealing process gradually became so apparent by experience, that all wheel-makers eventually adopted it in effect.

On August 7, 1849, J. Murphy, of Kensington, Pennsylvania, obtained a patent for a mode of cooling wheels with solid hubs, which was "to remove " them from the flask and chill as soon as possible, and place them in a case " of brick-work or other non-conductor or bad conductor of heat, which case " is so formed as to inclose all the wheel except the hub. . . . The joints " of the case around the spokes of the wheel are made air-tight by means of " sand, clay, or similar substance."

In 1849, Thomas S. Bourshett patented a wheel having a hollow hub and rim, connected with hollow spokes. This form of wheel was made about the same time by Mr. Mason, of Taunton, and used under trucks of the engines built by him; it was preferred on account of its neat appearance, and because the inside box could be oiled through the spoke; but, being a difficult wheel to cast, it has never been much used, except under trucks of engines, and to a limited extent under tenders.

In 1850, Nathan Washburn patented a wheel, having a double plate at the centre, and a single waved plate at the rim, with brackets or braces supporting the tread on the inside of the plate. This form of wheel is very strong, and is now used almost exclusively whenever double-plate wheels are required. These wheels have to be cooled gradually, to allow for the contraction, which is done by covering them in dry hot sand.

In 1850, George W. Eddy invented and patented a wheel, having the hub connected with the rim by a single plate on the outside, and wrought spokes on the inside. This wheel was lighter, and was sold for a less price than the double-plate wheel; it was strong, and on account of the manner in which the iron ran when the rim or tread was formed, was chilled deeper and harder, and had a more lasting chill than any other form. A 30-inch wheel of this form that had run on the Richmond & Danville Railroad for twenty-five years, and several which had run on the Philadelphia, Wilmington, & Baltimore Railroad twenty years and over, were exhibited at the Centennial Exhibition by the Lobdell Car-wheel Company. The objection to this wheel was that the wrought spokes have a tendency to make the hub on the side to which they were attached, hard and difficult to bore, and car-builders and others who had their work done by piece-work complained that they could not bore them.

From 1849 to 1860 the minds of many were directed in a remarkable degree to perfecting railroad wheels. During this period no less than eighty-eight patents were granted for alleged improvements, which consisted of making the plates of all conceivable forms, having curves and contortions that must have greatly exercised the ingenuity of patent agents to describe, as is shown by a few quotations from some of the claims, as follows: "Arch piece *b*, and the hollow annulus *c*, and the solid annular parts *d* and *f*;" "spokes, single-plate and double-plate combined;" "single-plate with curved arms thereon, reversed to the right on one side, to the left on the other;" "auxiliary or zigzag rims in said annular space;" "with a rim *c*, of the form of a semi-

ellipsis, and of an oblate spheroid *b*, with braces *d*, of the form of cyma-reversa and cyma-rectas," &c.; wheels with "sunk and raised panels;" wheels with "the multiplied and reversed or alternate corrugations of the plate or flanges," &c. None of the patents granted during this period, excepting those of Bourshett, Washburn, and Eddy, were of any importance, as they did not add to the strength or durability of railroad wheels.

In 1853 street railroads were opened in New York, though prior to this the New York & Harlem Railroad Company had conveyed passengers on their road in cars drawn by horses. In 1857 they were opened in Philadelphia and Boston, in 1859 in Pittsburgh, and in 1860 in New Orleans. The cars used on these roads required light wheels with narrow treads, which have been almost universally made with a single plate, or with spokes of wrought or cast-iron, the single waved plate being used by all wheel-makers, excepting Whitney & Sons, who make a wheel with a straight plate, and the Lobdell Car-Wheel Company, who make a wheel with a straight plate, with the addition of a rib on the inside of the tread, opposite to the flange. The latter also make a wheel with waved plate if desired. To meet the demand for a light wheel for horse-cars, wheels have been made by a few wheel-makers having a cast-iron hub and rim, and wrought staggered spokes; but they are difficult to cast and are expensive, and on this account have not been generally used. Light wheels for horse-cars are made by removing a part of the plate between each bracket or brace. It has been found by the Lobdell Car-Wheel Company that better wheels can be made, admitting a harder and deeper chill, by making them with cast arms or spokes, and of such shape that there will be no thin parts or edges to chill and cause them to crack. Wheels of this pattern were shown by them at the Exhibition, and they will bear chilling deeper than the light plate-wheels used for horse-cars.

In February 1861, George G. Lobdell patented what is known as "Lobdell's improved single-plate wheel," which differs from those made by others in the addition of a rib to the inside of the flange, which not only adds to the strength of the wheel, but has a tendency to make a more perfect chill at or near where the flange commences. In many wheels made without this rib the chill at this point is less in depth than at other places, and the flange, when worn sharp, is more liable to break.

Mr. George G. Lobdell also patented, in January 1869, the wheel known as the "Lobdell combination wheel," which is similar to the Washburn wheel; it is the Washburn wheel with the addition of a rib to the inside of the flange, and has the same advantages as the single-plate wheel. This wheel is very strong, cannot be broken in fair use if made with proper care and properly cooled, and can be as perfectly chilled as any form of wheel cast with the flange down.

In 1843, T. Perkins and W. McMahon, Baltimore, Maryland, obtained a patent for the method of fastening chilled tires for driving-wheels to the centres. The centre was turned conical, larger on the inside, the taper being about $\frac{1}{4}$ inch in 4 inches; the tire was held on by means of "gibs," placed in slots cut in the periphery of the centre, the gibs having a head on one side, which bore on, and fitted into, notches in the outside edge of the tire, while there was a nut on the inside end of the gibs. The idea was that the tire might stretch and require to be tightened, which was to be done by means of these nuts. This was found not to be necessary, because when properly fitted they never required tightening, and the nuts were not used. The gibs, when used, were put on hot and riveted on the inside end. The use of gibs was soon abandoned, and the tire was secured by bolts through the rim of the centre, which were either tapped into the tire a short distance or fitted into a recess in the tire. These tires were used for many years on the Baltimore and Ohio, the Pennsylvania, the Philadelphia, Wilmington, and Baltimore, and other railroads, both for passenger and freight engines, and are now used extensively on these roads under shifting-engines. When made with care, of the proper material, and selected so that the tires under an engine are of uniform diameter, they give a very great mileage. A tire made by Bush and Lobdell, and shown at the Exhibition by the Lobdell Car-Wheel Company, ran on the Richmond and Danville Railroad for fifteen years.

Until within a few years chilled wheels were made entirely of charcoal pig-iron, having proper qualities of chilling and strength, and of which there is a comparatively limited production, as all iron made with charcoal is not

suitable for making chilled wheels. The increase in our railways, and the consequent increased demand for chilled wheels, raised the price of charcoal wheel-iron to a high figure, and the wheels to a high cost. Under this state of things, William G. Hamilton, of the Ramapo Wheel Company, Ramapo, New York, began to experiment, with a view to discover a mode of using iron cheaper than charcoal wheel-iron, the result of which was that he found that steel, particularly Bessemer steel, melted in a cupola or other furnace with pig-iron, added strength and chill to weak and partially or non-chilling iron. For this a patent was granted to him December 22, 1868, and reissued February 25, 1873. About December 1871, A. Whitney & Sons, wheel-makers, of Philadelphia, began to experiment under Mr. Hamilton's patent, and obtained such satisfactory results in a few months' trial that they decided to use the mixture of steel with pig-iron at their works, under license from Mr. Hamilton's company. At that time, but a limited quantity of rails of Bessemer steel (which is best for the purpose) could be had in this country, as but few steel rails had been worn out, and it became evident that a demand for Bessemer steel scrap, from a few wheel-makers, would raise the cost of such metal higher than that of charcoal pig-iron. Experiments were therefore made in 1872 by A. Whitney & Sons with wrought-iron rail scrap, as a substitute for Bessemer steel, and it was found to add strength and chill to pig-iron, the same as Bessemer steel. A patent was granted to George Whitney, July 16, 1872, and reissued November 5, 1872, for the use of wrought-iron in chilled wheels. The patents of Mr. Hamilton for steel, and of Mr. Whitney for wrought-iron, in chilled wheels, are now the property of "The Hamilton Steel Wheel Company, of Philadelphia," under licenses from which a very large number of wheels have been made and are now made in this country.

The discovery of the advantages of steel and wrought-iron in the manufacture of chilled wheels seems second only to that of the slow-cooling and annealing process. The use of steel and wrought-iron has been the means of rendering available many brands of pig-iron less costly than charcoal pig, thus greatly reducing the cost of wheels to the consumer, and at the same time enabling the manufacturer to produce a stronger and more durable wheel than is possible by the use of pig-iron alone.

For several years past many of the wheels used under engines, tenders, and passenger-cars have shown defects of a character which did not occur before, and which are termed scabs, or blotches. Wheels of small diameter are more liable to have them than those of large diameter; and this liability also attaches to wheels used under heavy engines and tenders, and heavy cars that run at high speed. They have been more common since the introduction of the air-brake, occasioned, no doubt, by the severe grinding or abrading action on the surface of the wheels, which takes place in stopping the momentum of the train in the exceedingly short distance in which it is now done, by the use of the air-brakes. There appear to be incipient defects on the surface of the wheels, which do not extend to a great depth into the chill, but which the constant and repeated concussions of the wheels on the rails, or the slipping of one wheel when in motion (no two wheels ordinarily being of exactly the same diameter), develop into these blotches or scabs. What occasions these defects is a moot question among wheel-makers. They do not appear on the surface, and cannot be detected by any examination before being used; they are seldom found in wheels which have not a hard or deep chill. To determine to what depth they extend into the chill, and whether they would continue to be developed when in use, Mr. William W. Lobdell, of the Lobdell Car-Wheel Company, in April 1875, caused a pair of 26-inch truck-wheels, that had been used eleven and a half months on the Philadelphia and Baltimore Central Railroad, to be turned. These wheels showed a number of blotches, which were all removed by turning. They were then put under one of the heavy engines used on the Philadelphia, Washington, and Baltimore Railroad, where they were constantly in use until removed to be placed on exhibition at Philadelphia, having made 28,600 miles after the treads were turned. They are not worn out, but will be again used on the same road; they show no blotches or defects, and to all appearance may yet make 50,000 miles. This experiment led to turning off many others with the same success. As yet none have been in use long enough to be condemned, and none show defects of this character, proving that the defects, however occasioned, do not extend much below the surface. It also led to turning off new wheels, and established the fact that,

however much care is used in the preparation of the chill, no chilled wheels are perfectly cylindrical or of uniform diameters. By turning, these incipient defects are removed, the wheels are made of a uniform diameter and cylindrical; consequently there is no tendency to slip, and the wear is greatly diminished.

Mr. George G. Lobdell has recently invented, and put in use, in the shops of the Lobdell Car-Wheel Company at Wilmington, a lathe arranged to turn chilled wheels on the axle. With this lathe many wheels, heretofore condemned and sold as old material, on account of flat places in them, caused by sliding, can for a small sum be turned and made better than they were before. Wheels that are chilled to the proper depth, say five-eighths to three-fourths of an inch, may be turned more than once. It is believed that once turning will increase the mileage fully 50 per cent.

Elliptic Springs.

By Felician Slataper.

A brief and condensed report of railway springs from their first application and use in the United States, shows that the first in use were the leather or "thoroughbrace" springs, dating back to 1829 and 1830. The motion imparted by these springs to the coach body was principally a rocking movement with something of a lateral motion combining to give some relief, but accompanied upon rough tracks with an abrupt termination, which soon suggested the necessity of more elastic perpendicular motion.

Soon the same class of coach bodies which was running on four wheels was fitted with pedestal frames, with pedestals or "housings" for the axle-boxes. Above these frames, and between them and the bodies of coaches, four imported full elliptic springs were placed, each being directly (or nearly so) over the axle-box. These springs were quite correct in design, but could not furnish to the coach body the lateral motion required, which the former leather springs developed to some extent, nor could they neutralise the uncomfortable movements imparted by the road directly to the frame beneath. These defects soon developed the necessity of combining with some independent wheel-frames the springs and leverages necessary to absorb the abrupt motions from the road, and resting the coach body upon this last system of springs and levers. As early as 1829 the "bogy," or four-wheeled truck, was adopted; and the lateral movement (almost universally used at the present time) known as the swinging-bolster, was applied soon after. These principles seeming to be the perfection, practically and economically considered, of railway car-trucks, it remained only necessary to develop the proper arrangement, and then the most perfect construction of the various most approved railway springs then in the market.

Many car-trucks were as early as 1840 fitted with coiled or spiral springs, constructed of either flat or round steel of various grades of high or low carbonised steel. First, the trucks were without what are known as equalising bars reaching from axle-box to axle-box. This allowed springs to be placed upon them, which received the first shocks from the road at points near to or removed from the axle-boxes, and on some lines the springs were placed on the exact centres of these bars.

The necessity, in the earliest forms of car-trucks used, of placing the springs directly over the axle-boxes developed a class of springs which, while capable of resisting the shocks, reacted in an unpleasant jumping motion, frequently repeated too often to allow of either comfort or absolute safety. This soon led to the adoption of equalising bars, which allowed the movement of the axle-box and the springs to be relatively changed, and so adjusted as to give the springs a leverage and make their movements easier. The improved feature of equalising bars being now adopted, it remained to develop the combination and proportions of springs which should ensure the best results.

As early as 1844–45, rubber properly vulcanised for railway springs was applied; and it developed, especially in the trucks with equalising bars and swinging bolsters, a remarkable quality of absorbing or neutralising the noise and jarring motion of the springs of various materials then in use.

Many admirable qualities attach to rubber springs, and were it not for the effects of climatic changes upon them, and the difficulty of restraining their

tendency to bounce upon receiving sudden shocks from the road, they would be desirable for exclusive use under car bodies. They still retain qualities making them desirable in combination upon equalising bars with steel springs, and are often used in this way.

The hasty construction of railways, and consequent roughness of the tracks, made it necessary to develop some combination and character of springs suited to that condition, possessing the utmost durability that was possible, and as great economy as the roughness of the tracks would allow.

Up to this time, while the arrangements of the trucks were quite perfect, but little progress had been made in developing first-class elliptic springs, and those in use were constructed upon principles so contrary to correct theories that they required great quantities of steel to "hold up," and concentrated their action so much at particular points in the springs that not only was their motion almost completely destroyed, but their repairs, if any motion was developed, were constant and expensive. These conditions encouraged the continued use of inferior forms of springs, which were, however, from their inception, far more correctly constructed than the elliptics of that date.

The features of elliptics which make them unapproachable as springs are their slow motions to an almost unlimited extent, with their power of absorbing many disturbances in one motion, and the time they take to recover without abruptness from the immediate effects of such disturbances. The roughness of the common highways has made their use on all classes of vehicles imperative, and the same reasons prove conclusively that this form of spring can never be displaced or equalled upon railways until the common highways of the country can point to some other successful form of springs in use upon their surfaces.

A most creditable advance has been made upon American railways in the adaptation of springs comprehending the proper number of elliptics and their best arrangement, and this branch of railway equipment would now be in the very front of progress were it not that a great many trucks of early design are in process of wearing out previous to abandonment.

It is unnecessary to speak particularly of locomotive springs, further than to affirm that in their earlier uses the same defects of form existed as in car springs, and modification of the designs in the engines became necessary to meet the requirements of the improved springs now so generally and successfully used.

Of the use of elliptic crucible steel springs in freight-cars, it may be said that the high cost of this steel in the earlier applications made it necessary to construct short springs to keep the cost per car at a point to favour their introduction. Their action even under these unfavourable circumstances was so satisfactory as to encourage and procure the use of longer springs, which has also been favoured by the reduced cost of crucible steel.

At the present time many of the leading lines whose cars are subjected to heavy service, both in mileage and loads, have adopted crucible steel elliptic springs of sufficient length and capacity for their freight-cars to ensure durability beyond the life of the cars, and sufficient range of motion to make the cars safe at the highest rates of speed, and easy upon the roads with the heaviest loads.

Improvements in Branches of the Pennsylvania Railroad.

By Felician Slataper.

Railways, or tramroads, date back about two hundred years before the first introduction of steam-roads in this country. In fact, the locomotive appeared one hundred and ninety-nine years after the first tramroad in the coal regions of England and Wales, where a Mr. Beaumont received the credit, in 1630, of laying the first wooden rails for the transportation of coal. From that time improvements have been made, but very slowly at first, for it does not appear that iron rails were used until some hundred years after the year 1738; and the first locomotive was tried on rails in 1804. This was Trevithick's tram-engine, which, after running off the road, was degraded, and worked out its

existence as a stationary engine about twenty years before the time of any of the rail or tramroads of this country.

At that time, however, it would not have been said to be "degraded;" since, for a quarter of a century after, there seems to have been great doubt whether stationary power, at intervals of three miles, with endless rope, would not be better, and it was not until after that date that the locomotive was considered more practicable.

The State of Pennsylvania has the credit of the first locomotive used in this country, which was imported from England in 1829, one year before any were built in this country. And in August 1831, the "John Bull," which was shown in the Exhibition, was received at Philadelphia,—not the "John Bull" of the Mohawk and Hudson Railway, which is so often pictured as the "first steam train of America." The locomotive "John Bull" was built by Roberts, Stephenson, & Co., at Newcastle-upon-Tyne, England, for the Camden and Amboy Railroad; arrived at Philadelphia, August 1831; and was transferred to Bordentown, New Jersey, September 4, 1831. The original dimensions of this locomotive were 9-inch cylinders, with 20-inch stroke, one pair of drivers 4 feet 6 inches, and one pair of wheels 4 feet 6 inches, not connected. The hubs of the wheels were of cast-iron, spokes and felloes of wood, and tires of wrought-iron. Its total weight was ten tons. The engine was transported from Philadelphia in a sloop, and transferred by means of waggons to the tracks of the Camden and Amboy Railroad, at the Bordentown shops. The machinery was there put together, and a tender was constructed with whisky barrels upon a four-wheeled platform-car, which had been used by the contractor in the construction of the road. The connection between the pump of the engine and the crude tank thus formed was made by means of a leather hose, fitted up for the purpose by a shoemaker in Bordentown. The locomotive was first run by steam on September 15, 1831; and several trips were made before the first public trial, on November 12, 1831, when the members of the New Jersey Legislature and a number of other prominent persons were among the guests present. The general instructor and conductor of the train was Robert L. Stevens, with Isaac Dripps, engineman, and Benjamin Higgins, fireman. The "John Bull" remained at Bordentown until 1833, when the Camden and Amboy Railroad Company began running their cars by steam-power, the road having been previously operated by horse-power. The road was completed through to South Amboy in 1834, at which time this locomotive was placed in regular service, and continued in successful operation until 1866. As it was the first engine on the road, care was taken to preserve it, using it only as a curiosity, and since the lease of the New Jersey roads to the Pennsylvania Railroad it has been kept as a relic. This locomotive, together with the two cars placed on exhibition, were photographed some time ago, to represent the early rolling-stock of this country. The cars are of the following dimensions: 38 feet 4 inches from out to out of draw-bars; 8 feet 7 inches in width; height from rail to cornice, 10 feet 1 inch; from rail to top of car, 11 feet 1 inch. The construction of the cars was remarkably good, as they were thoroughly trussed. They originally had the doors on the side, without steps, as, at the time they were in use, the station platforms were sufficiently elevated to avoid that necessity. The seats were covered with cloth, and in lieu of blinds curtains were used.

To note the advance in rolling-stock of railways in the half-century hardly passed, it is only necessary to compare this exhibit of the Pennsylvania Railroad (the first train of the Camden and Amboy Railroad) with their present standard locomotives, as constructed from their drawings, by Mr. J. B. Collin, mechanical engineer, and exhibited by the Baldwin Locomotive Works. There were two on exhibition,—the one a standard "C" engine, designed for passenger traffic, and the other a standard "I," for freight traffic. The passenger locomotive, known on the Pennsylvania Railroad as the "C," is an eight-wheeled engine of the ordinary American type, and differs from the usual construction merely in some few of its details.

Boiler.—The boiler, which is of the waggon-top variety, is made of soft crucible steel, double-rivetted throughout. It differs from the usual construction merely in these points,—in having long stay-bolts extending from side to side between the crown bars; in having stays passing across the boiler between the tubes, supporting the flat sides of the slope (the part of the boiler which

forms the connections between the fire-box and the barrel of the boiler); in having the water-grate formed out of heavy wrought-iron tubes, one and seven-eighths inches diameter,—this kind of grate is used on some other roads,—and in the device for the consumption of smoke. The smoke-burning arrangement consists of a deflector formed out of large tiles supported upon four pipes, which are bent in a suitable manner, and extend from the throat to the crown-sheet.

Frames.—The frames are of the usual American construction, being formed out of bars four inches wide by two and one-half inches deep, the pedestals being welded on solid; as already stated, there is nothing peculiar about them, unless it be the manner in which the two parts of each frame are joined together. With most builders it is customary to carry the forward bar straight back against the front leg of the forward pedestal; and to bend down the top bar of the main portion of the frame, and bolt it to the front bar, thus forming a right-angled triangle, of which the top bar of the main frame is the hypothenuse. The result of this arrangement is that, when the strain comes upon a frame in this manner, the bent portion will yield, or spring, as it is called, and all the strain will come upon the straight part (often upon a single bolt), and this part will soon break its fastenings; after which the bent part of the frame is very apt to break also; in other words, the frame will break in detail because the parts do not "work together." In the Pennsylvania Railroad engine, the front bar, where it joins the main frame, is bent down so as to form an isosceles triangle with the top bar of the main frame; and the result is that the two parts spring alike,—*i.e.*, work together; and not a single instance is known where a frame made in this manner has broken (except in case of a bad weld), although many hundreds are in use.

Cylinders.—These are of seventeen-inch diameter, with twenty-four-inch stroke. They were designed some ten years ago. Perhaps their most important peculiarity is that they are symmetrical and interchangeable, so that one pattern will answer for both sides without alteration, the main steam and exhaust openings being central. The cylinders are bolted together in the centre, one-half of the saddle being cast solid with each cylinder.

Foot-Plate.—The foot-plate is made of cast-iron. Its peculiar feature is that it has heavy flanges projecting downwards inside the frames, and is secured to the frames by means of horizontal bolts through these flanges. In this manner a fastening is obtained which is an improvement on the old practice.

Driving-Wheels.—The design of the wheels was made some eleven years ago, and has been well tested. The centres, which are made of cast-iron, have hollow spokes, which are counterbalanced with lead; the tires are three inches thick, the driving-wheels are sixty-two inches in diameter.

Bridge-Pipe.—This name is given to a contrivance used for the collective supply of steam to the various small fittings which have usually a direct and independent connection with the boiler. This arrangement has been in use on the Pennsylvania Railroad for a number of years, and by this means the making of a number of small openings in the boiler is avoided.

Valve-Motion.—This is of the most common kind, consisting of shifting links and rocker-shafts, which transmit the motion to the valve.

Brake.—The engine is fitted with the Westinghouse air-brake on both tender and driving-wheels.

Scoop.—The tender has a scoop for picking up water while running. This scoop is made substantially upon the same plan as that originally invented by Ramsbottom; but some change in the arrangement and manipulation was found to be necessary in order to accommodate this ingenious contrivance to the American practice. In England, the scoop is let down before the engine reaches the trough, and when it comes over the trough the rails gradually sink down to a lower level, and the scoop is thus made to dip into the water, and in a similar manner comes up at the end of the trough by the rails gradually rising back to their former level. In America this plan was not practicable, owing to the interference of the "pilot," which would strike the trough if the rails were lowered, and it therefore became necessary to make such an arrange-

ment as would allow the scoop to be let down and taken up while the engine was over the trough. This was accomplished by counterbalancing the weight of the scoop and the greater portion of the pressure of the water by a strong spring; and after a little practice neither end of the trough was ever struck by the scoop.

THE FREIGHT-ENGINE.—The freight locomotive exhibited, known on the Pennsylvania Railroad as the "I," is constructed upon a plan similar to the consolidation type of engines, of which the Baldwin Locomotive Works exhibited one built for the Lehigh Valley Railroad Company; but it varies from the latter in some important particulars, and in some respects it might be called the improved "camel-back," because the boiler of the Pennsylvania Railroad engine is constructed substantially upon the same plan as that of the Winans engine. The reason for the variations in the plan of this engine from the original type was mainly found in a desire to prevent, if possible, the unusually rapid destruction of the flanges of the driving-wheels, which was characteristic of this class of engines. It was believed that this defect was due, in part at least, to an insufficient weight on the ponies and forward driving-wheels. How the weights are distributed on the Lehigh Valley Company's engine I do not know; but in a lot of engines of this kind, built by the Baldwin Locomotive Works after their own design, the weight (with the engine in working order) was about as follows:

On pony-wheels	9,250 pounds.
„ first pair of drivers	16,370 „
„ second „ „	21,280 „
„ third „ „	21,130 „
„ fourth „ „	22,990 „
Total	91,020 „

The total weight of the Pennsylvania Railroad engine is about the same, but it is distributed as follows:

On pony-wheels	12,240 pounds.
„ first pair of drivers	21,580 „
„ second „ „	19,200 „
„ third „ „	19,540 „
„ fourth „ „	19,680 „
Total	91,040 „

In order to obtain this result without increasing the wheel-base, it was found necessary to adopt a plan or boiler which would bring the weight forward. For this purpose no plan suggested itself that was better adapted to the purpose than the "camel-back," or Winans boiler, which, with slight modification, was found to lend itself with great readiness to the requirements of the design; and the result, thus far, seems to entirely justify the choice; as the boiler, besides effecting the desired change in the distribution of the weight, has proved itself a free and economical steamer, and costs less to build than a "waggon-top" boiler of the same power. As to the result of the change of weight in preserving the flanges of the tires, it can hardly be said that nothing remains to be desired, because, where these engines are used on portions of the road having many and hard curves, the flanges will still wear faster than could be desired; but the difficulty is much lessened, and on the easy portions of the road the flanges of these engines do not wear at all.

PONY-TRUCKS.—Next to the boiler, the most important variation from the original plan is in the pony-truck. This design was contrived for the purpose of getting rid of the springs over the journal-boxes, which prevented the lower portion of the frame from being extended forward to the support of the buffer-beam, and thus left this beam in an ill-supported position. This object was fully attained, and the truck itself appears to work as well as the old one.

MINOR VARIATIONS.—There are a number of other variations in this design, which it would be tedious to enumerate, but I will mention a contrivance for the distribution of the feed-water over the forward portion of the tubes. This

apparatus is based upon the following theory: In a locomotive, as ordinarily arranged, the feed-water sinks down below the tubes, and flows back towards the fire-box, until it encounters the upward current near the tube-sheet, when it is drawn into this current. It thus happens that the water is heated in that portion of the boiler which is most valuable for the generation of steam; whereas, if the low temperature of the forward portion of the tubes could be utilised for this purpose, something of a saving might be attained; but whether any benefit results from this arrangement has not been ascertained.

General Finish.—The painting and general finish of the engine is planned with a view to quiet and harmonious effect, and is based upon the principle that the purpose for which a locomotive is used does not admit of any merely ornamental devices; but that its beauty, so far as it may have any, should depend upon good proportions and thorough adaptation of the various parts to their uses.

Pennsylvania took an active part in developing a railroad and canal system of transportation; and in 1834 had a through route from Philadelphia to Pittsburgh:

From Philadelphia to Columbia	82	miles, railroad.
„ Columbia to Hollidaysburg	172	„ canal.
„ Hollidaysburg to Johnstown	36	„ railroad.
„ Johnstown to Pittsburgh	104	„ canal.
Total distance	394	„

With the exception of some coal roads, the Philadelphia & Columbia Railroad was the first built in Pennsylvania, and was operated at first by horse-power; and the thirty-six miles of Portage Railroad over the Alleghany Mountains was by a series of ten inclined planes,—worked by stationary engines,—having an aggregate length of 23,169 feet, with elevation of 800 feet rise and 1,202 feet of fall.

It was some time after this that the Pennsylvania Railroad was chartered, and commenced building its line west of Harrisburg, which was completed to connect with the Portage State Railroad, at Hollidaysburg, in 1850; and in 1852 the Western Division was completed, giving a through all-rail line between the coast and the waters of the Mississippi, using as the connecting link the old Portage road, with its inclines. This, however, was changed in 1854; and after the building of the new Portage Railroad by the State, all the State improvements were sold out to the Pennsylvania Railroad, and delivered to them on August 1, 1857.

The difference between the old Portage Railroad and the present Pennsylvania Railroad will show the advancement made in railroad tracks; the former being the forerunner of the latter, and described by Assistant Engineer G. C. McGregor as follows:

"The old Portage Railroad was built as far back as 1833, and was intended to be operated by horse-power. The original track of this road was very primitive in its construction being simply of granite, and wooden sills; to which were secured flat rails of strap-iron. This style in time gave place to the more substantial form, shown on figure 1 of the accompanying drawings, and which may be described as follows: Granite and locust ties, alternating with each other, and separated by granite blocks, served as supports for the rails. The rails, which were of a peculiar pattern, were secured to the supports by cast-iron chairs; the latter being fastened to the supports by bolts driven into wooden plugs, which were forced into holes previously made for their reception in these supports. This fastening was a source of much trouble and inconvenience, the bolts coming out of their places at the passage of nearly every train, necessitating constant attention. The wooden pegs with which the rails were secured in the chairs were for the same reason a source of considerable expense and annoyance. The rails, owing to their very narrow base, had to be supported about every three feet in order to keep them from turning over. This plan seemed to have been thought more economical than to increase the base of the rail, and do away with the large number of chairs. The length of the rail was about fifteen feet, and it was much lighter than those used at the present time."

The idea of bending rails for curves does not seem to have been considered in track-laying; and a curve at that time looked like a portion of a polygon of a decidedly finite number of sides. The builders compromised it by using short rails, the rule followed seeming to have been, "the sharper the curve "the shorter the rail." Good ballasting seems to have been a feature of very little importance. The road, when taken by the Pennsylvania Railroad Company, showed that little ballasting had been done. What ballast was used was broken sandstone. Drainage, now considered very necessary, was then thought of very little importance. In fact the entire road was very primitive, and the rattle and clatter of a train could be heard long before it approached.

Soon after the road came into the possession of the Pennsylvania Railroad the style of track was changed, and in 1859 a chair-joint with hemlock ties was used. About twelve ties to a twenty-five-foot rail were employed, which were found to give longer life to the rail, and cost less. The broad base was afterwards adopted, and spikes were used instead of bolts, as it was found impossible to keep the latter in place. The style of chair then in use allowed the rails to "creep," and to close up at some points and widen out at others. Besides, the joints, coming as they did directly on the ties, caused the rails to be very much battered at their ends. The "fish-joint," in use on one or two roads as far back as 1845, does not seem to have been introduced on the Pennsylvania Railroad till much later. The battering of the ends of the rails was in a great measure obviated by suspending the joint. The "creeping" of the rails was prevented by the introduction of the "stop-chair," of which there are a number of patterns,—one being a piece of plate-iron bent to fit to the fish-plate and the base of the rail. It is about three inches wide by seven inches long. Its lower end is held to the tie by two common rail-spikes, and its upper end is bolted to the outside of a fish-plate by one of the bolts which confine the fish-plate to the rail. Two chairs are used to a joint,—one at each end of the fish-plate. The angle fish-plate is now used in place of the stop-chair above described, and is found to be a very excellent form, which can be bettered by having the angle-plate on both sides of the rail. This double-angle fish-plate joint is now used on bridges and in tunnels. From the experience of the Pennsylvania Railroad it was found best to suspend the joint; and as stability of the cross-ties at the joints was essential, it was desired to have the road well ballasted, as a "churning" tie will soon destroy the best joint.

PENNSYLVANIA RAILROAD COMPANY.

Specifications for a Perfect Subdivision.

Superstructure.

1. The track must be in good surface; on straight lines the rails must be on the same level, and on curves the proper elevation as set down in the table (to be furnished each subdivision) must be given to the outer rail and carried uniformily around the curve. This elevation should be commenced from 100 to 150 feet back of the point of curvature, depending on the sharpness of the curve, and increased uniformly to the latter point where the full elevation is attained. The same method should be adopted in leaving the curve.

2. The track must be in good line.

3. The splices must be properly put on with the full number of bolts, nuts, stop-washers, and stop-chairs. The nuts must be screwed up tight.

4. The joints of the rails must be exactly midway between the joint-ties, and the joint on one line of rail must be opposite the centre of the rail on the other line of the same track. In winter a distance of five-sixteenths of an inch and in summer one-sixteenth of an inch must be left between the ends of the rails to allow for expansion.

5. The rails must be spiked both on the inside and outside on each tie, on straight lines as well as on curves.

6. The cross-ties must be properly and evenly spaced, sixteen ties to a thirty feet rail, with ten inches between the edge of bearing surfaces at joints, with intermediate ties evenly spaced a distance of not over two feet from centre

to centre, and the ends on the outside, on double track, and on the right-hand side going north or west on single track, must be lined up parallel with the rails.

7. The ties must not, under any circumstances, be notched, but should they be twisted, must be made true with the adze, and the rails must have an even bearing over the surface of the ties.

8. The switches and frogs must be kept well lined up and in good order. Switches must work easily and the signals kept bright and clean.

9. Particular attention must be given to avoid low joints at the head-blocks of switches.

10. There must be a uniform depth of at least twelve inches of clean broken stone or gravel under the ties. The ballast must be filled up evenly between, but not above the top of the ties, and at the outer end sloped off to subgrade.

Road-bed and Ballast.

11. When stone ballast is used, it must be broken evenly and not larger than a cube that will pass through a two and one-half inch ring. In filling up between the tracks, coarse large stones must be placed in the bottom in order to provide for drainage, but care should be taken to keep the coarse stone away from the ends of the ties.

12. The road-crossing planks must be securely spiked; the planking should be three-quarters of an inch below the top of rail, and two and one-half inches from the gauge line. The ends and inside edges of planks should be bevelled off.

Ditches.

13. The line for the ditch must be well and neatly defined, parallel with the track, at a distance of seven feet from the outside rail; the side next to the track must be made with a uniform slope from the bottom of the ballast to the ditch-line, where it must be at least twenty inches below the bottom of the cross-ties, so as to pass water freely during heavy rains and thoroughly drain the road-bed.

14. The necessary cross drains must be put in at proper intervals.

15. Earth taken from ditches or elsewhere must be dumped over the banks and not left at or near the ends of the ties, but distributed over the slope. Earth taken out of ditches in cuts must not be thrown on the slope.

16. The channels or streams for a considerable distance above the road should be examined, and brush, drift, and other obstructions removed. Ditches, culverts, and box drains should be cleared of all obstructions, and the outlets and inlets of the same kept open to allow a free flow of water at all times.

Policing.

17. The telegraph poles must be kept in proper position, and trees near the telegraph line must be kept trimmed to prevent the branches touching the wires during high winds.

18. All old material, such as old ties, old rails, chairs, car materials, &c., must be gathered up at least once a week and neatly piled at proper points.

19. Briers and undergrowth on the right of way must be kept cut close to the ground.

20. Station platforms and the grounds about stations must be kept clean and in good order.

By order of the General Manager.

WM. H. BROWN, Engineer Maintenance of Way,
No. 233, South Fourth Street, Philadelphia.

A short section of sample track was built at the Centennial Exhibition, after the present standards, on which the postal cars of the Pennsylvania and New York Central Railroads were placed, just south of the Government Building. This track received favourable mention in connection with the postal cars, and clearly showed the advance in railroads.

The postal car of the Pennsylvania Railroad was one of the limited mail cars, built after a plan of the Post Office Department, to carry the through

mail, and was placed on exhibition to show the manner of distributing the United States mails. These cars were sixty-four and one-half feet long, nine feet four inches wide, and were built, with all the interior work, in eleven days.

The request of the Post Office Department, that a fast mail service be established between New York and Pittsburgh, was made on August 26, 1875, and three cars, each with a tender, were ready for service at Jersey City on September 13. These were built in eleven days after the plans were received, which affords an example of the efficiency of the railroad shops of the present day.

The interior arrangements of these cars comprise numerous distributing pigeon-holes, of different sizes; the smaller ones, numbering seven hundred, are fitted with reversible bottoms, with labels on each end, the case being made of pine, faced with black walnut; the other boxes are large, and so arranged that, when full, the contents can be taken out from the back. There is also an office in the car containing a writing-desk and chairs, which are convertible into a bed if needed. The foregoing, in connection with closets, &c., make up the inside arrangements. The exterior of the car is painted white, and varnished, and lettered with gold leaf. The medallion in the centre contains a finely executed painting of the consulate seal of the United States.

The Hamilton Steeled Wheel Process.

The wheels used under these postal cars were made at the Altoona Wheel Foundry, which took a prominent part in the Hamilton Steeled Wheel exhibit at the Centennial, and under whose patents they were made. This exhibit although designed to show the great value of the mixture from which the wheels were made, gives a very good idea of the improvements in that branch of railroading.

For a proper understanding of the objects shown by the exhibit, Mr. Hamilton, the patentee, gave a description of the articles displayed, of the plant used in making the wheels, the metals used, results obtained, and reasons for adopting the process.

Description of Articles.—The wheels shown were: Two car-wheels, composed of mixtures of steel and anthracite pig-iron, taken from under Pullman passenger-cars, after making a mileage of 156,800 miles, and still good for service. One of the wheels was broken to show depth and nature of chill.—Three new wheels, of mixtures of steel and iron, to show pattern used.—One engine truck-wheel, which had made a mileage of 140,000 miles, and was good for future service.—One wheel, made of a mixture of twenty-five per cent. steel and equal quantities of anthracite and coke irons. This wheel was very strong, and had a deep chill.—To note the strength of the wheels: one wheel, with eight holes broken through the plate, and one in the hub, driven in by four hundred and twenty-five blows of a thirty-five pound sledge, the wheel being perfect in all parts except where struck by the sledge.—Two cases, containing specimens of various kinds of iron, combined with steel, in varied proportions, to show the increased strength given by the use of steel and chilling properties to non-chilling irons.

The progressive effect of chill and strength was clearly shown in an example of the effect of steel on Glendon anthracite iron, which was made equal in all respects to that of charcoal wheel-iron of the first quality.

Description of Altoona Wheel-Foundry and Plant.—The Pennsylvania Railroad Company put in operation, in 1874, the wheel-foundry erected at Altoona, which, to produce the greatest economical results, was fitted with the latest improvements, the more novel of which will be noted.

The building of brick, with iron rafters, and slate roof, is so ventilated as to entirely carry off the smoke and gas. Moulding-floor, 138 feet 10 inches by 71 feet 5 inches; annealing-room, 95 feet by 58 feet 7 inches; 2 Mackenzie No. 8 cupolas; plant capacity of each, 30 tons of metal at a heat.

Blowing-Engines—2 steam-cylinders, 16 inches diameter, by 30-inch stroke; 2 blowing-cylinders, 48 inches diameter, by 30-inch stroke, and 60 revolutions per minute, with 5 to 7 ounces pressure of blast to square inch; 13 hydraulic moulding-cranes.

Hydraulic pitting-crane, for annealing-room, with capacity for moving 400 wheels, weighing 220 tons, per day, by the aid of two men. One hydraulic lift, for charging furnace; one hydraulic wheel-breaking machine.

Reservoirs, of a capacity of twelve tons of metal, to secure melted metal from cupola, hung on trunnions and moved by hydraulic power.

Test-cupola, for testing metals, and steam-baths for tempering clay. The other appliances are similar to those in use in other works, but of a more solid construction.

The foundry is operated by 75 men, viz., 13 wheel-moulders, 1 general moulder, 55 labourers, 1 core-maker, 1 cupola man, 1 foreman, 1 assistant, and 2 clerks.

Wheel-moulding is paid for by the piece; average price paid, 35 cents per wheel; core-making, 8 cents per wheel.

Materials used in a charge of metal of 53,500 pounds for one cupola are as follows:

5,350	pounds	old steel rails, or	10	per cent. of charge.
3,745	„	No. 1 charcoal iron, or	7	„ „
10,700	„	No. 3 „ „	20	„ „
5,350	„	No. 4 „ „	10	„ „
12,305	„	No. 1 anthracite iron, or	23	„ „
7,490	„	old wheels, or	14	„ „
8,560	„	scrap from foundry, or	16	„ „
53,500	„		100	„ „

The best quality of Lehigh coal is used, 8,200 pounds to a charge, or in a ratio of one pound of coal to six and nine-tenths pounds of iron.

Mileage of Wheels.—The average mileage of wheels of this mixture under Pullman cars is 69,800 miles; under passenger-cars, with frequent action of the brakes, 46,423 miles, or an average mileage of 57,000 miles; a result not excelled, if equalled, by any cast-iron which is used in this country.

Reasons for adopting the Process.—Having in the foregoing given a brief description of the earliest plant and metals used, with mileage, it is now proposed to give the reasons for adopting the steeled-wheel process.

It will be noticed that in the above mixture of irons there is no white iron used to give low irons a chill, and that there is one iron—No. 1 anthracite—largely used. In other wheel-foundries a more or less per cent. of white iron is used to bring up the chill. It is a well-known fact that white iron has comparatively little or no strength. The introduction of such an article can only deteriorate the strength of the melting-iron. By the use of steel, a great advantage arises in the avoidance of white iron, as steel is the strongest known composition of chemically pure iron with any combination of foreign substances. The benefits of using steel are:

First. That it brings into use, for the manufacture of car-wheels, non-chilling irons, such as low-grade charcoal (warm-blast) irons, anthracite, coke, and raw coal irons.

Second. That it is a means of using advantageously old steel rails, steel, and wrought-iron scrap, which have low market value.

Third. That, by bringing into use low-grade irons, having a consequently low price, a larger assortment may be used, thereby controlling the market and price of metal to a great extent.

Fourth. That, when the proper mixtures are obtained, a much stronger wheel than the ordinary make of cast-iron wheel will be the result.

Fifth. That the grade of chill can readily be controlled.

Sixth. That a better blending of the gray pig with the white iron will be effected.

In order to arrive at these advantages it is necessary,—

First. To have a highly-carbonized iron, such in proportion of graphite as the No. 1 anthracite used.

Second. That it be of a soft, open-grain nature, uniform in grain and in bulk, as put in the furnace.

Third. In the use of anthracite coke iron, it is preferable to have an iron of a non-chilling character, as then a sufficiency of steel can be used to give the strength.

Having the iron, we must next consider the action of steel upon cast-iron in the cupola, and the conditions necessary to produce the best results. The action of steel upon cast-iron in the cupola is that of reducing the carbon, as steel contains a much less percentage of carbon, having only one-half of one per cent. to two and one-half per cent. (·5 per cent. to $2\frac{1}{2}$ per cent.), cast-iron two and one-half per cent. to five per cent. of carbon ($2\frac{1}{2}$ per cent. to 5 per cent.).

The reduction takes place under the following conditions :

That there is enough melted cast-iron in the hearth or crucible of the furnace to take up the steel; and that it is of sufficiently high temperature to rapidly fuse and carbonise the steel. The steel coming in contact with the melted cast-iron, and enveloped by it, it immediately takes up the carbon and becomes cast-iron. The law of uniformity makes the resulting mixture an average of the two constituents, having a greater or less per cent. of carbon, in accordance with the respective percentages of each used.

The cost of production is cheapened by the process. Independent of making available many brands of charcoal irons, besides those generally known and used for car-wheels, the cost is reduced from the fact that suitable steel can be obtained from ten to fifeeen dollars per ton less than the standard car-wheel irons; and anthracite and coke irons from ten to twenty dollars less per ton than car-wheel irons. Thus, in the cost of a car-wheel weighing five hundred and fifty pounds, the use of ten per cent. of steel and twenty-five per cent. of anthracite iron with high grades of charcoal iron, will give a reduction of fourteen per cent., while by the use of steel the lower grades of charcoal irons can be used successfully, and a reduction of fully twenty-five per cent. can be made.

This reduction in cost has been fully proved in the operations of the Altoona Foundry, in making over ninety thousand wheels by this process. The mileage returns at the same time compare favourably, and in most cases exceed the mileage of wheels made entirely of charcoal iron from the most renowned makers. The Pennsylvania Railroad Company thus fully recognise the claims made for the process of economy in first cost, and safety and durability in service.

The wheel-foundry thus described is only a portion of the Altoona Railroad shops, in each branch of which great improvements have been made.

GENERAL REPORT

ON

GROUP XX.

MOTORS, HYDRAULIC AND PNEUMATIC APPARATUS, &c.

JUDGES.

American.	*Foreign.*
CHARLES T. PORTER, Newark, N. J.	WILLIAM H. BARLOW, C.E., Great Britain.
JOSEPH BELKNAP, New York, N. Y.	FRANCIS REULEAUX, Germany.
HORATIO ALLEN, South Orange, N. J.	NICHOLAS PETROFF, Russia.
CHARLES E. EMERY, New York, N. Y.	EMIL BRUGSCH, Egypt.

E. N. HORSFORD was temporarily assigned from Group X. to assist in the examination of fire-hose and belting.

GENERAL REPORT.

MOTORS, HYDRAULIC AND PNEUMATIC APPARATUS, &c.

By Charles E. Emery.

The exhibits referred to this group included in general the motors operated by vapours, gases, or fluids, and apparatus for the generation of steam; together with machinery for moving or operating upon gases and fluids, such as blowers and pumps; also, apparatus for the transmission of power and numerous incidental devices relating to the several subjects. Each of these branches was so very well represented that it has not been considered practicable or advisable to atlempt a general description. It is proposed simply to put on record brief notes in relation to exhibits, or classes of exhibits, which, in the opinion of the writer, are of historical interest in connexion with the growth of a particular industry; which suggest improvements for the future, or which, from some feature of importance or novelty, deserve special mention.

The Judges of Group XX. desired to make practical trials of several classes of the articles exhibited, and although circumstances prevented the design from being carried out to the extent intended while the services of the foreign members were available, a number of trials were made by committees, reports of which will be referred to hereafter.

Hydraulic Exhibits.

The hydraulic exhibits contained few features of novelty, but the display was, in most branches, very complete, and the arrangement such as to attract public attention, and give each exhibitor an opportunity to show his apparatus to the best advantage. The greater portion of these exhibits was located in the Pump Annex to Machinery Hall, in which was a pool or tank 160 feet long, 60 feet wide, and 8 feet deep, located in the centre of the building, below the floor level. The pool usually contained about five feet of water, and was connected with a series of channels or small canals, extending under the floor to different parts of the building, from which the various pumps received water, thereby obviating the necessity of small tanks for each exhibit. The water from the several power and steam pumps was discharged into the main pool at so many points, and with such variety and force in the direction of the streams, as to form a very interesting feature of the Exhibition. The discharge pipes were generally carried over the passage surrounding the pool, and in some cases the water simply flowed from the ends of the horizontal pipes and fell in curves some 12 feet into the water. The ends of some of the pipes were turned downward, and one had a cup-shaped attachment to the bottom, over which the water flowed in an annular sheet. One exhibitor had several hose-nozzles arranged at the north end of the pool to throw water its entire length; another directed nozzles upward, and kept wet the roof of the ventilating gallery, about 70 feet above. There were in all some 70 streams playing into the pool, of which 8 were 6 inches in diameter or upward, and 22 were contracted nozzles, to give velocity to the issuing streams. The effect, when all the pumps were at work briskly, was quite pleasing, and would compare with natural scenes in animation and interest, if not in beauty. At the southern end of the pool an artificial waterfall, 36 feet wide and 32 feet high, was exhibited at certain hours of the day, the water for the purpose being supplied to an elevated tank by centrifugal pumps.

The pool was provided for in the plans of Messrs. Wilson and Pettit, the engineers and architects of the building; the arrangement of the exhibits being under the direction of the Bureau of Machinery.

Pumping Engines.

The largest and most expensive hydraulic exhibit was the pumping engine for supplying the entire Exhibition grounds with water, which was furnished by Mr. Henry R. Worthington, of New York, and was located on the west bank of the Schuylkill, just outside the inclosure,—the stand-pipe, 120 feet high and 208 feet above the river, being within the grounds, near the Art Gallery. The engine was of the Worthington duplex type, with a capacity of 6,000,000 gallons daily. There are two horizontal double-acting pumps with plungers 22¼ inches in diameter, arranged side by side on the same frame, each operated directly by a compound engine with steam jacketed cylinders 29 and 50¼ inches in diameter,—the strokes of engines and pumps being 4 feet. The smaller steam cylinder is attached to the front head of the larger and has a central piston-rod connecting with the pump-rod through a cross-head, and two piston-rods from the larger cylinder pass outside the smaller and connect with the cross-head. There are two single-acting air-pumps, each 29¾ inches in diameter, with 24 inches stroke, which are operated from the ends of a horizontal beam with vertical lever attached, receiving motion from one main cross-head. The main valves are plain slides operating over double-cylinder ports as described hereafter. The valves for both cylinders of each engine are arranged on the same stem by raising the chest of the smaller, and each valve is provided with a balancing piston. The valves of one engine are operated by bell-cranks directly from the reciprocating parts of the other, and no rotative movements with accompanying details are required. As previously stated, double-cylinder ports are provided. The outer ones receive steam past the ends of the valve and admit it to the cylinder in the usual way. The inner ones communicate with the exhaust cavity of the valve only, and enter the cylinder at such distances from the ends that when steam is exhausting through one of the ports the main piston will run over and close it and cushion upon the vapour thereby inclosed, the outer port being at the time shut off by the main valve. Valves are provided to put the two cylinder ports at each end in communication to regulate the extent of cushioning. The pump-valves consist of rubber disks, arranged in chambers above and below the plungers. Each plunger runs without packing in a long grooved ring in a central diaphragm. In operation, one engine while in full action moves the valves of the other, when the pistons of the latter gradually begin to move, and finally attain full velocity as those of the first are checked by the steam-cushions and gradually come to rest,—the pump-valves meantime seating quietly. The first engine pauses a moment till the second engine admits steam, when it commences a return stroke and the second comes to rest,—the action of one blending into that of the other as each alternately takes up the load,—the result being that the discharge is uniform, a uniform pressure is maintained in the main, and the pumps under heavy or light pressure operate without jar or noise.

The remarkable contrast between engines of this type and the well-known Cornish engines, both in construction and operation, will be appreciated from the above. In Cornish and other engines, non-rotative and rotative, in order to practically use steam with considerable expansion it is necessary to attach to the moving parts heavy masses of metal, which being accelerated, when pressures are high, absorb work, which is yielded up with a corresponding reduction in velocity as the operating pressures decrease. In the Worthington engines the weight and friction of moving parts are reduced to a minimum, and the elastic force of the steam practically acts upon the water column directly, whereby is secured simplicity of construction and smoothness of working, with a material reduction of frictional resistance, also freedom from the danger incident to handling the heavy weights in the original form of non-rotative engines. The expansion of steam in the Worthington pumping-engine is determined principally by the difference in the size of the compound cylinders, and is sufficient in connexion with the freedom from jar and the low resistance of engines and pumps to secure duties which are quite high when it is considered that the maximum steam pressure so far employed is only 40 pounds. The official test of one of these engines at the Newark Waterworks, New Jersey, showed a duty of 77,358,478 pounds of water raised 1 foot with 100 pounds of coal. The engines show regular average

yearly duties as high as 60,000,000, in which fuel necessarily expended on account of stoppages is included.

In Philadelphia a number of engines of different kinds are employed at the different pumping-stations. The following is extracted from the annual reports:—

Pumping Station.	Type of Engine.	Cost of raising one million gallons one foot high.				
		1872.	1873.	1874.	1875.	1876.
		Cents.	Cents.	Cents.	Cents.	Cents.
Belmont	2 Worthington duplex	7·00	7·68	7·08	7·84	7·07
Roxborough	1 full Cornish and 1 Worthington duplex	9·90	9·92	9·19	10·30	9·51
Delaware	1 high and 1 low-pressure rotative, and 1 Worthington duplex	13·20	13·14	14·35	12·98	12·69
Schuylkill	2 full Cornish, 1 double-cylinder rotative, 1 bell-crank rotative	11·20	17·36	16·97	17·05	13·40
Germantown	1 high-pressure rotative	36·20	—	—	—	—

On the whole, the evidence appears to be that the Worthington duplex engines give higher average performances than any other class of pumping-engines in use in the United States, except those especially designed to secure economy of steam, and in comparison with those it is proper to consider differences in interest on first cost of engines and of their foundations, and also, in some cases, questions as to the ease of management and reliability for extended use under practical conditions.

It is stated that, when the load is thrown off from a duplex engine, as has happened by the breakage of a pipe, the steam-cushion prevents damage during the first stroke, and afterwards the action of the duplex valve-gear is to so shorten the strokes that no injury can occur. In the same building with the pumping-engine was exhibited a Worthington duplex pump similar to the engine, except that each pump-plunger was operated by a single cylinder.

Mr. Worthington exhibited also in the rooms of the American Society of Civil Engineers, in the west gallery of the main building, models, drawings, and descriptions of considerable historical interest. He undoubtedly originated and introduced the first direct-acting steam-pumps ever constructed,* and by his success created a demand for pumps of all kinds. A specimen was shown, complete, of his first form of pump as developed in the years 1840–44. In this pump the steam-valve is partially reversed by tappets and levers connecting with main piston-rod,—the throw being completed by a spring and arrow-headed bolt. The general features of this plan have been repeated many times since. Mr. Worthington afterwards constructed several pumps in which the main valve was operated by an auxiliary piston, as in the more approved modern forms; a portion of one of this kind being exhibited. These pumps are said to have worked well, but were ahead of the times, and in 1849 the Worthington & Baker pump with relief-valve motion was brought out, which was very favourably received, and created the demand now so well supplied by many manufacturers. To this pump, it is believed, the m, or double cavity steam slide-valve, now universally used in steam-pumps, was first applied. It is employed with the ordinary arrangement of cylinder ports on an elevated face, but steam enters under the end of the valve, at the end of the cylinder opposite that supplied by an ordinary single cavity-valve when moved in the same direction. The pump consisted simply of a steam-cylinder and plunger-pump, with an arm on the piston-rod extended upward to operate tappets on the valve-stem. As the pump neared the end of the stroke, openings in the pump-plunger were uncovered, thereby admitting water from one side of the plunger to the other and relieving the engine of load, when the stroke was completed, by the expansion of the steam

* The Cornish and other pumping-engines without rotating parts are of course excepted.

in the cylinder, with such velocity as to insure the operation of the steam-valve by means of the tappets. Ericsson is reported to have said of one of these pumps that it represented greater efficiency, for a given number of parts and quantity of material, than any machine he had previously seen. The largest pump constructed with this valve-gear had a capacity of 300,000 gallons per day, and was erected in 1854, to supply the city of Savannah with water. It was provided with an annular compound steam-cylinder, and was running regularly two years since. The sudden reversal of motion at the end of the stroke with this valve-gear made its application to larger engines not desirable. The plan of using a large number of small pump-valves was first applied in the year 1850, substantially as shown in Fig. 2, and the system in various forms is being adopted by manufacturers. As compared with the heavy double-beat valves usually employed in pumping-engines, the small valves require less lift, produce less jar, and offer less resistance to the passage of the water. The Worthington duplex engine was perfected about the year 1859, and from 1860 to 1876 no less than 80 were erected in different parts of the United States and Canada, with capacities varying from 500,000 to 15,000,000 gallons daily. For engines of moderate size, the two pumps are severally operated by cylinders of different sizes, the steam exhausting from one to the other through an intermadiate receiver.

The type of pumping-engine designed and patented by Mr. E. D. Leavitt, and constructed by I. P. Morris & Co., of Philadelphia, was illustrated at the Exhibition by a drawing in the rooms of the American Society of Civil Engineers, previously mentioned. The engines are compound beam-engines, with a Thames Ditton bucket and plunger-pump, and are especially designed to secure economy of fuel. The pump connects to one end of the beam, the main connecting-rod to the other. The bottoms of the high and low-pressure cylinders are located close together at the centre of the frame, and their tops incline outward toward the ends of the beam, by which arrangement the strokes of the pump, of both main pistons, and the throw of the crank are equal. The cylinders are steam-jacketed. The main valves are of the gridiron pattern, and reduce the spaces in clearance, &c., to a minimum. The first engine of this kind was put in operation in Lynn (Massachusetts) in the year 1873, and showed, on trial, the remarkable duty of 103,923,215 pounds raised 1 foot high with 100 pounds of picked Lackawanna coal, with less than 8 per cent. refuse; the duty being based on the pressure in the main by gauge plus the pressure due to the height of gauge above water in the pump-well, increased by one pound for estimated resistance in suction-pipe, &c., and on the entire displacement of the pump, without any allowance for loss of action, which latter, by weir trials, was found to be 4 per cent.

A pair of these engines tested in Lawrence, Massachusetts, in 1876, showed an average duty of 96,186,979 foot-pounds for 100 pounds of Cumberland coal, the duty being estimated from actual quantities, except that the actual delivery over the weir at the reservoir was increased 5 per cent., as provided for by contract, to allow for loss of action in the pump. These results rival those obtained with the best English pumping-engines. A duty of about 93,000,000 was obtained previously with an engine at Lowell, designed by Mr. Robert Briggs, which was tested on the same basis. The principal dimensions of the Leavitt engines in operation at the time of the Exhibition are as follows:—

	Lynn.	Lawrence.
Number of engines	1	2
Diameter of high-pressure cylinder, inches	$17\frac{1}{2}$	18
Diameter of low-pressure cylinder, inches	36	38
Diameter of pump-barrel, inches	$26\frac{1}{16}$	$26\frac{1}{8}$
Diameter of plunger, inches	$18\frac{1}{2}$	$18\frac{1}{2}$
Stroke of engines and pump, feet	7	8

A large working model of the Davey compound differential pumping-engine was exhibited by Messrs. Paulding, Kemble, & Co., of the West Point Foundry, New York. Usually the pump and compound cylinders of these engines are arranged horizontally on the same frame, with the smaller cylinder nearest the pump and its piston-rod connecting to the pump-rod through a cross-head, which also receives two rods from the larger cylinder extending alongside the smaller. Usually the main valves are plain slides,

with considerable lap, having an equalizing port running through the metal outside the central cavity. The valve receives a so-called differential movement from an intermediate point in a lever, one end of which is moved, through suitable reducing levers, by the main piston, but in the opposite direction, and the other by a cataract engine. The latter consists simply of a steam-cylinder, the piston of which is connected to that of a regulating cylinder, in which a fluid is displaced from one end to the other through a graduated opening. The valve of the cataract engine also receives motion from the differential lever.

Let it be supposed first, that the main and cataract pistons are moving in the same direction, the latter slightly in advance, and tending to open the main valve, while the movement of the main piston tends to close it. If the pressure overbalances the load the main piston will run ahead and thereby cut off a steam-supply so that the stroke will be completed by expansion. In any case, before the main piston reaches the end of its stroke, the valve of the cataract engine will be shifted so that the direction of that piston will be reversed, and, from the compound movements, the main valve will be shifted soon after, so that the motion of the main piston will also be reversed, and follow in the same direction as the cataract piston,—when the operations will be repeated. When the main valve is shifted near the end of the stroke, the main piston remains at rest, permitting the pump-valves to seat quietly. In case of accident, whereby the load of the engine is thrown off, the main piston will move ahead of the cataract engine, and steam be shut off.

This simple valve-gear, therefore, 1, distributes the steam; 2, regulates the expansion to suit the load; 3, secures the desired pause at the end of the stroke to permit the pump-valves to seat quietly; and, 4, acts as an efficient safety apparatus. Simple modifications of this valve-gear are applied to Cornish engines, and the various forms of single and compound engines. The system has been largely used in England, and has been introduced on the Pacific coast of the United States. Drawings were exhibited in the rooms of the American Society of Civil Engineers by the Risdon Iron and Locomotive Works of San Francisco, California, illustrating large pumping-engines, with the Davey valve-gear, in process of construction for mines in that vicinity. Their introduction in the eastern part of the United States is being prosecuted by the exhibitors.

In connexion with the subject of pumping machinery, the following extract from a monograph on the waterworks of Philadelphia, from 1801–15, by Frederick Graff, C.E., communicated to the exhibit of the American Society of Civil Engineers, will be found of historical interest, as showing by comparison the advances made at the date of the Exhibition.

The paper first states:—

"The first steam-engine of any considerable size appears to have been introduced into America and put to work about the year 1763, at the Schuyler Copper Mine, situate on the river Passaic, New Jersey. All of its principal parts were imported from England, and Mr. Hornblower (the son, it is believed, of the well-known steam engineer of that time) came to this country for the purpose of putting up and running the engine.

"About the year 1800 the manufacture of the engines for the Philadelphia Waterworks was commenced; and as late as the year 1803 we find five steam-engines only noticed as being in use in this country, as follows:—

"Two at the Philadelphia Waterworks; one just about being started at the Manhattan Waterworks, New York; one in Roosevelt's Saw-mill, New York; one in Boston; and a small engine used by Oliver Evans to grind plaster of Paris, at the corner of Ninth and Market Streets, Philadelphia.

"The engines for the Philadelphia Warerworks were manufactured by Nicholas Roosevelt, at works established by him near the Schuyler Copper Mine above referred to."

Then follows an extract from a report made in 1800, setting forth the difficulties in boring the cylinder for the engine of the waterworks on the Schuylkill at the foot of Chestnut Street. The paper continues:—

* * * * * * * * * * *

"The cylinder was 38½ inches diameter and 6-feet stroke, and drove a double-acting pump 17½ inches in diameter and 6-feet stroke.

"The engine at Centre Square, built about the same time and at the same place, had a steam cylinder 32 inches diameter and 6-feet stroke, and worked a double-acting pump of 18 inches diameter and 6-feet stroke, raising the water into tanks about 51 feet high.

"In both these engines the lever-beams, the arms and shafts of the fly-wheels, the bearings upon which the fly-wheels were supported, the hot wells, the hot and cold water pumps, the cold water cistern, and even the steam-boilers, were all made of wood. These latter were rectangular chests, made of white pine planks 5 inches thick; they were 9 feet square inside at the ends and 14 feet long in the clear, braced upon the sides, top, and bottom with oak scantling 10 inches square, the whole securely bolted together by 1¼ inch rods passing through the planks. Inside of this chest was placed a fire-box 12 feet 6 inches long, 6 feet wide, and 1 foot 10 inches deep, with vertical flues, six of 15 inches diameter and two of 12 inches diameter; through these the water circulated, the fire acting around them and passing up into an oval flue situated just above the fire-box, carried from the back of the boiler to near the front, and returned again to the back where it entered the chimney. This fire-box and flues appear to have been at first made entirely of cast-iron; then a wrought-iron fire-box was made, the flues still being of cast-iron; this not being satisfactory on account of the unequal contraction and expansion of the two metals causing leakage, eventually wrought-iron flues were also put in.

"Great advantage was at the time supposed to be gained by the non-conducting powers of the wood, and also by the vertical flues in the fire-box.

"By experiments made with the engines when the above described wooden boiler was in use, it was recorded that the engine at Chestnut Street, on the Schuylkill, while lifting the water to the height of 39 feet, and running at a speed of 16 revolutions per minute, raised 1,474,500 ale gallons of 232 cubic inches each in 24 hours, with a consumption of 70 bushels of Virginia coal. And the engine at Centre Square, raising the water 51 feet, pumped 962,520 ale gallons in 24 hours, with a consumption of 55 bushels of the same kind of coal; the pressure of steam in both cases being 2½ pounds to the square inch.

"As might be expected, great difficulty was experienced in keeping these boilers steam-tight; accordingly, on December 1,1804, a boiler with cast-iron shell, as well as flues, was put up, and another one, also of cast-iron, but of different form, was put in use March 10, 1806. The second of these, which was erected at the works on the Schuylkill, had semi-circular ends, was 17 feet long and 8 feet wide at the bottom, and 19 feet long and 10 feet wide near the top; the flame passed under the bottom and around the back into oval flues which pass through the boiler, returned, and passed around the sides outside the shell.

"The first had a semi-circular top, the ends being flat, and was erected at Centre Square. The fire passed under the boiler around heaters of peculiar construction, and through one flue of serpentine plan to the front of the boiler; this boiler had two sheets of wrought-iron upon the bottom, just over the fire, all the rest being cast-iron.

"These boilers remained in use until the steam-works at Fairmount were started, September 7, 1815."

It would require too much space to follow in detail the history of the pumping-engines in the United States from the time included in Mr. Graff's paper to the date of the Exhibition. Several important pumping-engines, which are interesting from peculiarities in construction, were put in operation during that period, of which it is probable but few will be duplicated.

In the year 1847, Mr. Erastus W. Smith, then superintendent of the Allaire Works, New York, designed an engine for the New Orleans water-works, involving the very important and unsual modification of arbitrary motion of valves in the pump. This engine was erected and performed successfully.

Cornish "bull" pumping-engines were erected in Buffalo in 1850. After running a number of years extra plungers were applied, and the steam pressure was increased to increase capacity. These same engines were altered into compound rotative engines afterwards, for which the original construction was not well adapted.

Messrs. Sickles & Dickerson, in 1856-57, constructed engines for Hartford, Connecticut, and for Detroit, Michigan, designed to rectify the inequality of the crank movement as applied to pumping, and to secure in a superior degree

the advantages due to the expansion of steam. The arrangement of the pumps of the Hartford engine has been described as follows: "The power was communicated through a pinion on the crank-shaft engaging a spur-wheel on either side of it. On each spur-wheel shaft were two cams; each cam gave motion to a set of pumps by means of bell-cranks; each set of pumps was composed of two pistons or boxes in one chamber or cylinder, one above the other, and moving independently of each other,—the piston-rod of the lower box passing through the upper piston-rod, which was made tubular." The cam motions were so contrived that each piston commenced before the other had completed its stroke. The pistons "commenced the stroke slowly, increasing to the uniform velocity, and then decreased for a little distance before stopping." There were, it will be seen, eight pumps distributed through the circle of rotation, but as they were operated by a single steam-cylinder, using a high degree of expansion, the result was not as expected. The mechanical difficulties with the Detroit engine were so great that it was abandoned and removed.

A beam pumping-engine, without rotative parts, was erected at the Brooklyn Water-Works about the year 1857, which was designed to use steam expansively in both ends of the cylinder. It became necessary, however, in order to secure even moderate expansion, to add mass in the form of heavy segments vibrated by connection to the main piston-rod. A rotative beam-engine erected at the works in 1869 operated so well that a duplicate of the original engine was altered to the same plan. The original design had two pump-buckets moving in opposite directions, in a continuation of the same pipe,—a system apparently so advantageous that it is worthy of further trial.

In the year 1861 a non-rotating pumping-engine, of unsual size, having a capacity of 800,000 gallons per hour against a head of 170 feet, was erected at the Cincinnati Water-Works, from the designs of Mr. George Shields, engineer in charge. The main cylinder, air-pump, and main pumps are all in the same vertical line. The engine is very bold in design, and excellently constructed, but the mass in motion is comparatively so small that the operation is practically without expansion, like an enormous steam-pump. There are at Cincinnati, in addition to the above, several excellently-constructed rotative beam and vertical pumping-engines; also a pair of horizontal high-pressure engines of the Western river steamboat style, applied for operating pumps. In a practical trial made in the year 1872, the latter were found to give more economical results than either of the low-pressure engines.

An interesting engine was erected several years since at the High Service Pumping-Works, Providence, Rhode Island, by Mr. George H. Corliss, the celebrated engine-builder. Five horizontal steam-cylinders and five horizontal steam-pumps are arranged radially, with pistons connected to a crank on a central vertical shaft to regulate the strokes,—no fly-wheel being employed. The work heretofore available at that station has not been at all sufficient for the size of the engines, but the system as such appears to offer advantages in obtaining uniformity of flow. During the Exhibition, Mr. Corliss was perfecting, by careful experiment, a compound engine with horizontal steam-cylinders.

Excellent results have been obtained in some locations with simple horizontal engines connected to horizontal or vertical pumps, and in engines of this class at Pittsburgh the lever connections are arranged to reduce the velocity of the pump-piston in relation to that of the steam-piston at the latter part of the stroke, so as to permit expansion.

The first important compound pumping beam-engine in the United States was erected in the year 1872, at the Schuylkill Works, Philadelphia, and was built from designs of Mr. Frederick Graff, chief engineer of the Water Department. The original engine of this type was, it is believed, constructed by Messrs. Simpson & Co., of the Grosvenor Works, Pimlico, England, and erected at the Bristol and Richmond Water-Works, in the year 1848. The system has been since extensively adopted both in England and this country. The Leavitt engines and the engine at Lowell, previously mentioned, are of this general type, and a pair of engines of this kind, with Corliss valves, which were in process of construction by the Quintard Iron Works, New York, during the Exhibition, have since been erected in Chicago, and gave, on trial, tested singly, an average duty of 97,575,050 foot-pounds per hundred pounds of coal.

During the period mentioned there were erected a considerable number of excellent engines of the well-known Cornish and beam rotative types. A large Cornish engine was put in operation in Providence, Rhode Island, while the Exhibition was in progress.

The number of Worthington and Leavitt pumping-engines erected previous to the Exhibition has been stated already in connexion with a description of the exhibits.

Steam-Pumps.

The steam-pumps formed a very large portion of the exhibit in the Hydraulic Annex. A complete description of the display, or of all its special features, would be tedious. The nature of the exhibit as a whole, and the importance of the steam-pump industry, may be judged from the accompanying list of the pumps shown by two of the more prominent exhibitors, in connection with which the more interesting features of the valve-gearing of direct-acting pumps will be briefly explained.

The Knowles Steam-Pump Works, Warren, Massachusetts, exhibited the following: One pump, for water-works with steam-cylinder 42 inches in diameter, and water-cylinder 22 inches in diameter, the stroke of piston being 36 inches; one pump, with composition-covered plunger, $18 \times 7 \times 24$,—the figures for brevity referring to the diameters of the steam and water-cylinders or water-plungers, and length of stroke in the order named; one plunger-pump, $24 \times 10 \times 24$; a vertical syrup-pump, with composition plunger, $16 \times 10 \times 24$; one oil-line pump, $14 \times 4 \times 24$, with ball pump-valves; one local oil-line pump, $6 \times 3 \times 7$, with ball pump-valves; one blowing-engine, $18 \times 48 \times 48$; one air-pump, with leather valves, $10 \times 20 \times 16$; one vertical mining-pump, Cornish pattern, $10 \times 8 \times 48$. Also other pumps of various sizes, designed for fire purposes, for lifting water to tanks, for feeding boilers, for attachment to locomotives, and other purposes; there being thirty-four pumps in all, several of the smaller ones being nickel-plated. All were of tasteful design, with parts finished to gauges with the greatest accuracy; finished bolts and nuts were used throughout, and all the joints ground to go together without packing of any kind. The value of this exhibit, as shown by the price-list, exceeded $27,000.

The George F. Blake Manufacturing Company, Boston, Massachusetts, exhibited the following: One $20 \times 18 \times 24$ wrecking-pump, capacity 2,600 gallons, at 100 strokes per minute; one $20 \times 14 \times 24$ water-works pump, capacity 1,000,000 gallons per 24 hours; one $18 \times 9 \times 36$ mining-pump, with patent removable water-cylinder, for gritty or bad water; two fire-pumps, one $20 \times 9 \times 24$, and one $14 \times 7 \times 12$; one $18 \times 5 \times 18$ oil-line pump; one $14 \times 2 \times 12$ hydraulic pressure pump; two double-plunger mining pumps, one $28 \times 16 \times 24$, and one $20 \times 10 \times 24$; one $8 \times 8 \times 8 \times 10$ combined air and circulating pump, for marine-engines; one $16 \times 18 \times 12 \times 24$ combined vacuum and water-pump, for vacuum-pans; one $6 \times 4\frac{1}{2} \times 7$ vertical, deep-well pump, piston pattern, double-acting; three sizes of combined pumps and boilers, complete for railroad water-stations, and a large variety of small pumps, such as boiler-feeders, tank-pumps, pumps for breweries, refineries, tanneries, gas-works, soap-factories, &c. The exhibit comprised five car-loads of material, and its value, per price-list, was about $24,000. All the work was well finished and of a substantial character, well adapted for the purposes intended.

Most of the pumps exhibited were of the direct-acting type, though a few crank-pumps where shown. The term direct-acting pump is used to signify not only that the steam and water-pistons are directly connected, but that the movement of the main valves is derived from that of the main piston, directly or indirectly, without the use of rotary motion to regulate the stroke or operate the valves. One kind of direct-acting pump stores up energy by compressing a spring, or the like, during part of the stroke, and releasing it to move the valve. A pump of this kind exhibited had details very similar to the original Worthington pump of 1840, previously referred to. Another pump, exhibited in Brewers' Hall, had a single-acting steam-piston, instead of a spring, to complete the stroke of the valve; and the initial movement was made by a cam and series of links in a very ingenious manner.

In most of the direct-acting pumps, however, auxiliary steam-pistons are provided to move the main valve. In operation, the main piston first moves

the valve of the auxiliary cylinder, when the piston of the latter moves the main valve; and, as the movements are successive with the better class of valve arrangements of this kind, one piston or the other will always be in position to act, and the pump will start and operate by simply admitting steam, or even water under pressure. A great amount of study and experiment have been expended on valve-gear of this character, and the problem is a difficult one, notwithstanding the apparent simplicity of the apparatus. In operation the main piston, as it nears the end of its stroke, must by a tappet connexion, or equivalent, move the valve of the auxiliary cylinder, and the auxiliary piston move the main valve quickly enough to prevent the main piston from striking the cylinder-head, and yet not so suddenly as to produce injurious jars in the pump end. This requires that the valve operating the piston shall start promptly when steam is admitted to it; that it shall move for a time at a higher velocity than the main piston; and that then the mass of matter in motion, consisting of the auxiliary piston and main valve, shall be suddenly brought to rest without noise, if possible, and at least without destructive jar. Each one of these requirements has been met in various ways. The initial movement to the auxiliary valve has been given by tappets and reducing arms, variously arranged, both inside and outside the cylinder, while in other cases no tappet at all is used, but the main piston acts as a valve, to cause steam to give the initial movement. The problem of starting and controlling the auxiliary pistons has led to many curious arrangements of passages, combined with all kinds of cushions, both internal and external. These plans could not be made plain without a number of engravings and extended explanations, but the general principles are more easily explained than the same can be carried into practical operation. A common plan is to provide separate steam and exhaust-ports for the auxiliary cylinders, and when the auxiliary piston nears the end of its stroke, it runs over and closes its exhaust and cushions on the inclosed steam. Steam is admitted again, either by carrying a double port to the valve-face, as shown in the Worthington pumping-engine, and patented for auxiliary cylinders by Mr. L. J. Knowles, or but one port is provided in the valve-face and two in the cylinder, the outer one of the latter closed by a check-valve, which opens toward the cylinder when steam is admitted to the port. The latter plan, substantially, is used in the Blake pumps. Others use ordinary slide-valves for auxiliary valves, and have separate cushioning arrangements inside or outside of the steam-chest. In another arrangement the main piston passes over a small opening, which admits steam from the cylinder to move the auxiliary piston. Many pumps of this class will not start in all positions. In the Knowles pump the lower surface of the auxiliary piston acts as the auxiliary valve, and by giving this piston a slight rotary movement steam and exhaust-ports are opened, to cause longitudinal movement, such movement closing both the steam and exhaust-ports, near the end of the stroke, so as to check the velocity both by cushioning and expansion; and, in addition, if the piston moves beyond a certain point, steam is admitted to check and return it slightly. The reverse rotary movement opens reverse ports, and the operation is repeated. In the Knowles pumps, and those exhibited by Mr. William D. Hooker, of Dedham, Massachusetts, double ports are provided at each end of the main cylinder, as in the Worthington pumping-engines, by which means the main pistons are gradually brought to rest by the steam-cushions, the pump-valves seat quietly, economy is secured, and greater speed may be attained.

A compound steam-pump, with cylinders in line, was shown by Mr. A. Carr, of New York, and an annular cylinder compound steam-pump by Messrs. Hillis and Jones, of Wilmington, Delaware.

A number of vacuum-pumps were exhibited, all founded on the principle of the original Savery pumping-engines, but with self-acting valves. In all cases there are dual chambers, which are provided with induction and eduction water-valves. To explain the operation: suppose a partial vacuum in one chamber, with water entering it, and steam in the other chamber forcing water out. The water entering the first chamber reduces the vacuum, and at the same time the water in the second chamber is lowered, so that a jet of water enters the steam and produces such rapid condensation that the pressure becomes less than in the first chamber, and an automatic steam-valve, operated by the difference of pressure in the two, is shifted, and admits steam to force the

water out of the first chamber, while the steam in the second chamber is at once condensed, forming a vacuum, thereby causing water to rise in it, when similar operations are repeated. Some of the exhibitors provide a small check-valve in each chamber, for the avowed purpose of interposing a film of air between the seam and water. In the pumps exhibited by Nye, Gourlay, and Co., of Chicago, Illinois, the cylinders are lined with wood, to reduce condensation. The "Pulsometer" pumps, exhibited by Mr. J. A. Grosvenor, of Jersey City, New Jersey, are of a tasty and pleasing design. The New York Hydraulic and Drainage Company arranges a number of vacuum-cylinders in gangs, and operates the steam valves at regular intervals by external power. The pump-valves provided with these cylinders are given an unusually large area to reduce resistances.

Duty of Pumps.

The duty of a vacuum-pump may be readily ascertained by simply noting the height of lift, and the initial and final temperatures of the water lifted. All the heat of the steam not expended in work enters the water, and the work performed lifts the same water. The difference in temperature gives very nearly the number of heat-units imparted to each pound of water lifted, and each pound of water so heated is lifted a certain number of feet high, so the result may be expressed readily in foot-pounds per heat-unit, and this may be changed into terms of the conventional duty of pumping-engines by simply fixing upon a standard to represent the number of heat-units imparted to water by one pound of coal. Inasmuch as the duty of pumping-engines is conventionally expressed in the number of foot-pounds obtained by the consumption of 100 pounds of coal, and as a pound of coal in a good boiler will evaporate over nine pounds of water at such pressure as to impart 10,000 heat-units to the water, or 1,000,000 heat-units for 100 pounds of coal, the writer has proposed the latter as a convenient basis of comparison, since the number of foot-pounds per heat-unit evidently expresses also the duty in millions of foot-pounds per 100 pounds of coal. For ordinary comparison, the number of millions duty equals the lift divided by the difference between the initial and final temperatures of the water. For more accurate computations, the divisor should be increased by the number of heat-units expended for work per pound of water lifted, which equals the height divided by 772. The height preferably should be calculated from the indications of a pressure-gauge at the bottom of the discharge-pipe, so as to include frictional resistances. If D = duty in foot-pounds per 100 pounds of coal, H = the height of lift per gauge, and t and T = the initial and final temperatures respectively, then

$$D = \frac{1{,}000{,}000\ H}{T - t + \cdot 0013\ H}.$$

Arrangements have been made by the writer to use the same basis in testing pumping-engines, by discharging water from the hot well into the suction of the main pumps, and noting the resulting increase of temperature with delicate thermometers.

A vacuum-pump tested by the writer in 1871 gave a duty, on the above basis of $4\frac{7}{10}$ millions; one tested by Mr. J. F. Flagg at the Cincinnati Exhibition in 1875, reduced to the same basis, gave a maximum duty of $3\frac{25}{100}$ millions. Several vacuum and steam pumps, tested on this basis at the suggestion of the writer about two years since, gave duties reported as high as 10,000,000 to 11,000,000, the very small steam pumps doing no better apparently than the vacuum-pumps, which is by no means surprising. Elaborate experiments made with steam-pumps at the American Institute Exhibition of 1867,* showed that average-sized steam-pumps do not, on the average, utilize more than 50 per cent. of the indicated power in the steam-cylinders, the remainder being absorbed in the friction of the engine, but more particularly in the passage of the water through the pump. Again, all ordinary steam-pumps for miscellaneous uses require that the steam-cylinder shall have 3 to 4 times the area of the water-cylinder to give sufficient power when the steam is accidentally low; hence, as such pumps usually work against the atmospheric pressure, the net or

* See Report of Messrs. Holmes, Selden, and Emery, Judges, etc., *Transactions American Institute*, 1867-68.

effective pressure forms a small per-centage of the total pressure, which, with the large extent of radiating service exposed and the total absence of expansion, makes the expenditure of steam very large. One pump tested by the writer required 120 pounds weight of steam per indicated horse-power per hour, and it is believed that the cost will rarely fall below 60 pounds; and as only 50 per cent. of the indicated power is utilized, it may be safely stated that ordinary steam-pumps rarely require less than 120 pounds of steam per hour for each horse-power utilized in raising water, equivalent to a duty of only 15,000,000 foot-pounds per 100 pounds of coal on the same basis adopted for the vacuum-pumps. With larger steam-pumps, particularly when they are proportioned for the work to be done, the duty will be materially increased.

Fire-engines.

Full descriptions of the construction and performance of the steam fire-engines are given in the report hereto appended, on trials of these engines made under the direction of a committee of the group.

The exhibit of chemical fire-engines, fire-extinguishers, etc., was quite complete. In one of the latter, exhibited by Messrs. Murphy and Harle, of Montreal, Canada, air was compressed above the water to avoid the damage resulting from the escape of the materials used for the generation of carbonic acid gas. The well-known extensible fire-ladder of Mrs. Scott-Uda was also exhibited.

Centrifugal Pumps.

The two centrifugal pumps, for lifting water into the tank for the waterfall, together with the engines operating them, were furnished by Messrs. William D. Andrews and Brother, New York. One pump, with a scroll-shaped case, had a capacity of 7,000 gallons per minute, at a speed of 285 revolutions per minute. It was operated through two leather belts, with V-shaped sections, by an oscillating engine, with a cylinder of 20 inches in diameter and 15 inches stroke, running 150 revolutions per minute. The other pump, with a cylindrical case, had a capacity of 8,000 gallons per minute, at a speed of 270 revolutions per minute. It was operated through one leather belt, of V section, by an engine similar to that above referred to.

The pump first above referred to was of the type designated by the manufacturer the "Anti-Friction Pump." Openings through the cone-shaped disc serve to balance the pressure on the two sides of the latter, and nearly neutralize the longitudinal thrust. Water passes from the suction pipe through the wheel without abrupt changes of direction. A scroll-shaped discharge-pipe keeps the water in motion in nearly the same direction in which it leaves the wheel, and the energy stored up in the mass of water at its high velocity is utilized in urging forward the column. The results of the trial of one of these pumps, made in the year 1870, are shown in the following table:*

Number of Experiment.	Duration of Experiment.	Revolutions of Pump per Minute.	Gallons of water delivered per Minute.	Average Head.	Dynamometer Horse-Power.	Net Horse-Power.	Per-centage utilized.
	Seconds.						
1	30	552	1,204	19·55	9,752	5,949	61·00
2	30	526	1,105	19·55	8,323	5,463	65·64
3	40	489	863	19·47	5,689	4,247	74·64
4	40	552	1,208	19·75	10,000	6,454	64·54
5	40	529	1,279	19·75	9,117	6,385	70·02
6	40	497	931	19·50	7,163	4,687	65·44

The pump tested had a discharge orifice of 6 inches diameter; the water was received from the side of a large tank, and was delivered under a head varying, for the different experiments, from 19½ to 19¾ feet. The lower part of the discharge-pipe was 6 inches in diameter, but it rapidly expanded to 12 inches diameter, which size was continued up to a tank about 3 feet square, over one side of which the water flowed into a chute, so suspended that the current could

* Report of Messrs. Emery, Pierce, and Magee, Judges, etc.—*Transactions American Institute*, N. Y., 1870–71.

be quickly directed either into a measuring-tank or back to the receiving-tank. The pump was driven by a steam-engine, through a countershaft carrying one of Neer's dynamometers.

It was considered that the results shown in the table should be increased, for the reason that the belting got wet and had to be made very tight; but as this was a matter of estimate, a column referring thereto in the original table has been omitted. The net horse-powers shown were calculated from the weights of the water and the heights lifted, no allowance being made for friction in the pipe. Without correction the percentages utilized are quite high. The highest recorded efficiency we have observed is that of the large Appold pump at the London Exhibition of 1862. From the report of D. K. Clark, it appears that that pump lifted about 16,000 gallons of water 6 feet high per minute, utilizing 73·74 per cent. of the indicated power of the engine. Allowing 10 per cent. for the friction of the engine, the pump itself utilized nearly 82 per cent. of the power applied. The water was measured by weirs, and was used over and over again, whereby air was liable to be carried through and to reduce the weight lifted, which was obviated in the test above referred to by the use of tanks.

The other centrifugal pump used to supply water for the waterfall, as referred to above, was known as the "Cataract" pump. The shape of the blade resembles the ogee form developed by Rankine.* This pump operated throughout the Exhibition very effectively, but its comparative efficiency is not known.

The engines used for operating the Andrews pumps are of the oscillating type, the distribution of steam being effected by an arc-shaped valve-seat on the bottom of the steam-cylinder, concentric with the trunnions, with the ports operating, as the cylinder moves, in connexion with passages in a valve-face on a stationary chest supported in the frame. The engines are remarkably simple and compact, but no provision is made for securing economy by the expansion of steam.

The centrifugal pumps exhibited by Messrs. Heald & Sisco, of Baldwinsville, New York, operated efficiently at the Exhibition, and gave excellent results in practical use. This pump requires a slower speed than many others, for which reason it has been used by the writer as a circulating-pump for several small steamers, and operated by direct connexion to a small engine. This pump has given good results on trial, but these have never been published, and are not accessible.

An efficient pump was also exhibited by Messrs. White, Clark, & Co., also of Baldwinsville, New York; and a number of manufacturers of hand-pumps, hereafter referred to, had centrifugal pumps of the ordinary pattern in operation, but which possessed no features of special interest.

Centrifugal pumps of excellent design were exhibited also by Messrs. Neut & Dumont, of Paris, France, and by Gwynne & Co., of London, England.

Messrs. J. & H. Gwynne, of the Hammersmith Iron-Works, London, England, exhibited a highly-finished model, illustrating the centrifugal pumping machinery used in the reclamation of the Ferrara Marshes in Northern Italy, which is by far the largest pumping machinery of any kind ever constructed. There are eight pumps, arranged in four pairs, each pair being driven by a compound engine. The pumps have 5-feet disks, and discharge-pipes 54 inches in diameter. The cylinders of each engine are respectively 27¾ and 46⅝ inches in diameter, the stroke being 27 inches; the mean lift is 7 feet 3 inches, the maximum 12 feet. The capacity of the eight pumps at mean lift is 57,000 gallons per minute, or 656,640,000 gallons per day. This would supply a stream 135 feet wide and averaging 3 feet deep, running uniformly at a speed of two miles per hour, which is much greater than the summer flow of many well-known rivers,—that of the Thames, England, for instance.

Some interesting examples are available showing the application of centrifugal pumps to dredging operations. In a paper by General Q. A. Gillmore, U. S. Engineers,† are recorded the results of using such a pump in deepening the channel over the bar at the mouth of St. John's River, Florida. The

* See Parson's paper, *Proceedings* (British) *Institute of Civil Engineers*, vol. xlvii. p. 267.
† Van Nostrand's *Eclectic Engineering Magazine*, September, 1872.

paper states that "upon this bar the ocean swell, which constantly prevails, "is of such exceptional magnitude and violence, that the usual method "of dredging into lighters or scows ordinarily pursued in still water is entirely "impracticable." An Andrews pump was used with suction and discharge pipes 9 inches in diameter, which was operated usually at about 315 revolutions per minute. The paper states: "This speed in the No. 9 pump is "equal to the work of raising 3,000 gallons of clear water per minute 30 feet "high, through a 9-inch straight vertical pipe. The actual height raised "above the water on the St. John's bar varies with the amount of sand taken "on board, from 10 to 11 feet, but as the pipes are 50 feet long, with bends, "and are in two branches instead of one, and as a mixture of sand and water "is heavier and more impeded by friction than clear water, the loss by friction "from all these causes combined reduces the useful work of the pump con-"siderably below the average attainable under more favourable conditions. "For these reasons, although 200 revolutions of the pump-disk per minute "will easily raise 3,000 gallons of clear water 12 feet high through a straight "vertical 9-inch pipe, 300 revolutions are required to raise 2,500 gallons of "sand and water 11 feet high through the two inclined suction-pipes having "two turns each, discharged through a pipe having one turn. To prevent "the ends of the suction-pipes being lifted off the bottom by the pitching of "the boat, and as a precaution against accident, a portion of each pipe is "made flexible, being composed of 6-inch rubber hose stretched over a coil "of wire. In addition, the ends are loaded with an iron frame or drag, each "weighing about 250 pounds, which is intended to move flat along the "bottom during the operation of dredging. To the under surface of this "frame, directly below the mouth of the pipe, a number of teeth or knives "are attached to stir up the sand and aid its entrance into the pipes." . . . "The proportion of sand that can be pumped depends greatly upon its "specific gravity and fineness. The calcareous and argillaceous sands flow "more freely than the silicious and fine sands, and are less liable to choke "the pipe than those that are coarse. When working at a high speed, 50 to "55 per cent. of sand can easily be raised through a straight vertical pipe, "giving for every 10 cubic yards of material discharged 5 to 5½ cubic yards "of compact sand. With the appliances used on the St. John's bar, the "proportion of sand seldom exceeded 45 per cent., generally ranging from "30 to 35 per cent. when working under the most favourable conditions." An accompanying tabular statement shows that the average number of cubic yards removed per minute during the time the dredge was in operation varied from ·73 to 1·12 yards, and that the cost varied from $0·26 to $1·22 per yard, the average cost for 128 days work being about $0·67 per yard.

In the improvement of Galveston harbour, Major Howell, U. S. Engineers, employs a centrifugal pump to fill the gabions with sand after they are located in place.

Captain Eads, at the date of writing, has just completed a large dredge, provided with a 30-inch centrifugal pump, designed to regulate and maintain the channel between the jetties at the mouth of the Mississippi River.

Rotary Pumps.

Most of the rotary pumps exhibited were in principle equivalent to a pair of spur-gear wheels, with coarse pitch inclosed in a case, the teeth of one operating as the wheels roll together to displace the fluid between the teeth of the other. As is well known, the appearance of these pumps may be much varied by altering the number and shape of the projections, which correspond with the teeth in the above general description. A number of fans used for the displacement of air, showing modifications of the above system, are illustrated under the head of "Blowing Machinery," *q. v.* There were also several small pumps, both American and foreign, with eccentric disks and vibrating abutments, and others with arms sliding through the disks. The only rotary pump with special novel features was that exhibited by Messrs. Bagley & Sewall, of Watertown, New York (the L. D. Green patent). An eccentric ring, secured through a disk to the main shaft, runs externally in contact with the inside of the pump-case and internally in contact with the exterior of a stationary ring. The receiving port is located in the side of the

case below a sliding abutment, and a delivery port is in a corresponding position above. Between the abutment and eccentric are tumblers, which adapt themselves to all movements, and secure tightness. The displacement is alternately between the eccentric and case, and the eccentric and inner ring, the latter being made sufficiently deep to maintain a uniform flow of fluid.

Propeller Pumps.

The Hydrostatic and Hydraulic Company, of Philadelphia, Pennsylvania, exhibited the Shaw compound propeller pump, consisting simply of small propeller blades revolving in a pipe between similar stationary blades of reverse pitch, the currents thereby being forced upward in a spiral direction.

In the double propeller pump exhibited by Geo. A. Follensbee, of Lewiston, Maine, the vanes of two series of propellers on parallel shafts and running in opposite directions act alternately on the water and urge it directly forward without the spiral movement.

The efficiency of propeller pumps as compared with centrifugal pumps is not known.

Domestic Pumps.

The space on the wall side of the west aisle, in the Pump Annex, was for about two-thirds the length of the building occupied by three exhibits of pumps for domestic and factory uses, and considerably more space was used by these and other exhibitors in other parts of the building.

The invention of pumps is attributed to the Egyptians, before the Christian era, but there could have been no rational explanation of the action of the suction-pump until about 1643, when Torricelli explained the true nature of a vacuum. The material generally employed for the first pumps—wood—is still largely used for such purposes; even the quaint pump-logs of our fathers are seen on the advance lines of civilization. More shapely forms, requiring less material, are, by the aid of modern tools, manufactured largely in districts where wood is cheaper than iron. Of this class the exhibit of Messrs. Biggs & Wells, of La Fayette, Indiana, were good examples. The Toledo Pump Company showed improved forms, in which the inner cylindrical surface, which receives the weir of the bucket, was lined with various materials suited to the kind of water: for instance, cast-iron enameled, but usually thin copper, lapped at the joints, so as to expand and contract with the wood. The application of iron in pump construction was commenced in some of the earlier pump-factories by applying iron tops to the ordinary pump-logs. Examples of this kind were shown among the exhibits from Canada, portions of which dominion are comparatively new. The records of the United States Patent Office show that improvements in pumps were numerous from the first. We observe that in 1833 Messrs. J. & J. Reed, of Plymouth, Massachusetts, took out a patent for a cast-iron pump.

The manufacture of pumps on an extended scale, as a special business, appears to have been first commenced by Messrs. W. & B. Douglas, of Middletown, Connecticut. This firm was established in 1832, and claims to have originated the principal designs for the metal domestic pumps now so generally known and used. The firm made a prominent display at the Exhibition.

The manufacture of pumps was commenced at Seneca Falls, New York, about the year 1840, by the firm of Paine & Colwell, which met with such success that two other firms soon commenced the same business. One was the well-known firm of Cowing & Co., which was succeeded in 1864 by the firm of Rumsey & Co., which made a prominent exhibit; the other, that of Downs & Co., which was succeeded by the Gould's Manufacturing Company, which also made a prominent exhibit. A similar manufacture is also conducted by the Union Manufacturing Company, of New Britain, Connecticut, which also exhibited.

The Seneca Falls manufacturers undoubtedly had much to do with the design and introduction of many of the familiar forms of pumps now so widely

known, and their modern styles are on the whole superior in the beauty of the designs.

It is impossible to detail all the varieties of pumps made to suit various locations and uses. All the manufacturers exhibited pumps for ordinary wells, for deep wells, for cisterns, for use on sinks, in various forms, with spouts, and with pitcher-tops, etc., and of every variety and size. Force-pumps were shown, single and double acting, in equal variety. Variations were made, too, in the kind of material; some pumps being of iron, others of brass, and others of a combination of the two. Some of the pump-barrels were enameled, others tinned or galvanized, and a few were shown with glass cylinders, properly secured, designed to suit the particular fluid operated upon. Certain forms of pump were mounted on wheels, and in form, size, and finish made suitable for fire or garden engines, for raising and distributing liquid fertilizers, and like uses. The business includes large reciprocating pumps and centrifugal pumps, driven by power, and rotary pumps operated by hand or power; also, hydraulic rams, hose carriages and carts, and matters of detail in connexion with the general subject, too numerous to mention.

The displays of the Gould's Manufacturing Company, of Seneca Falls, New York; that of Rumsey & Co., of the same place, and that of W. & B. Douglas, of Middletown, Connecticut, were quite prominent. The firm last named appeared on the whole to show a greater variety of styles, but the Gould's Manufacturing Company had the most attractive display. The details and workmanship of the pumps exhibited by all the manufacturers were substantially the same, except that the Douglas firm simply "smooth-bore" their pump-barrels, and the other firms polish them. Messrs. Rumsey & Co. report that they annually make nearly 100,000 pumps. Several of the firms estimate the value of the pump-industry in the United States at $1,000,000 to $1,250,000 annually, and probably two-thirds of the business is done by the several firms at Seneca Falls, New York. The pumps are exported largely to all parts of the world where agricultural or labour-saving machinery is introduced.

There were few domestic pumps shown in the foreign departments. Mr. C. Blunck, of Norway, exhibited several varieties of pumps of this kind in connexion with cocks, valves, ornamental cast-iron fonts, etc.; the exhibit being quite complete, considering the distance that it had been brought. A small well-finished fire-engine was included in the exhibit from the Netherlands.

Messrs. Thomas Haynes & Sons, of London, England, exhibited the "Hydronette," a hand fire- and garden-engine, made with telescopic tubes in direct continuation of a length of hose, the simplicity and efficiency of which was surprising. In connexion with an air-chamber, called the "Water Bringer," water could be drawn a long distance. A very convenient hose-carriage, for garden use, was included in the exhibit.

Driven Wells.

All the pump manufacturers exhibited points for driven wells, and pumps for operating in connexion with them. The driven well is one of the most important inventions of the age, as will be seen by contrasting previous methods for obtaining water with the simple means latterly available.

Wells, which were doubtless developed by gradually deepening open pools and walling them in for protection, have in all ages been of paramount importance. In the times of the patriarchs, large districts in the East, located at a distance from natural fountains and water-courses, were made habitable only by the existence and possession of these artificial reservoirs, the construction of which in those lands, with facilities then available, was an enterprise of the greatest magnitude. Wells were then princely inheritances, and determined the locations of the feeding-grounds of the flocks, the lengths of journeys, and the sites of cities. During the thousands of years since that time, wells in other countries, if not so sacred or valuable, were still an absolute necessity, and any improvements tending to produce economy or efficiency intimately concerned all nations; yet, with the exception of artesian

wells, which are of comparatively limited application and involve great cost and risk, no improvements were made, and wells to supply the every-day uses of mankind remained unchanged until the invention of the driven well, in the year 1861, by Colonel H. M. Green, then of Cortland, New York, which is now controlled by Messrs. William D. Andrews & Brother, of New York City.

The invention grew out of the exigencies of the civil war, and the want of some means to quickly procure an abundant supply of water, protected from the danger of its being poisoned by an enemy, and procurable by some device easily transported, and capable of repeated use and removal, to meet the necessities of a moving army. Previous to that time it had been considered necessary to have a reservoir of water below the earth's surface, which could be drawn upon at will, and would fill again gradually by percolation through the porous strata of the soil or cavities in the rocks. The discovery of Colonel Green was that no reservoir was necessary, but that, by creating a partial vacuum at any point in the earth below the natural water-level, water would be forced to such point by the pressure of the air in quantities unattainable by the use of a reservoir. The apparatus for utilizing the discovery consists simply of a tube driven into the ground to a sufficient depth, shod at the bottom with a perforated point, and provided at the top with an ordinary suction-pump, the operation of which creates a partial vacuum at the bottom of the pipe, and brings to the surface a copious and continuous supply of water. As is well known, it is easy to exhaust the supply in an ordinary well, and it is evident that the time required to fill it again, or to maintain a certain level, while water is being withdrawn, as the case may be, will depend upon the velocity with which the water will percolate through the porous soil or rock down an obstructed hydraulic slope, from the natural height of the water in the vicinity to the reduced height in the well. When, however, the reservoir is dispensed with, and suction is brought upon the porous strata direct, the influence extends over a very large area, and water flows in from all directions, the small cavities or spaces between the particles of rock or soil acting as so many supply-pipes, through which water is forced by the atmospheric pressure with an intensity proportioned to the vacuum attainable. The natural head of the water in the soil above the bottom of the tube balances a corresponding head within, so that the height of lift does not depend upon the length of pipe, but upon the depth of the natural water-level below the surface, and the head upon the particular stratum reached.

The simplicity and utility of the invention led to its rapid introduction. It is estimated that there are over one million such wells in use in the United States. The well received early recognition in England and France. The English Army in Abyssinia, in 1867–68, were furnished material for two hundred of these wells, of which some forty were placed permanently on the line of march, and the remainder transported with the moving army for temporary use. Their construction and care were placed in charge of Lieutenant Le Messureau, of the Royal Engineers, and a special corps of assistants, who drove the wells at each halting place, withdrawing and removing them whenever the march was resumed. Thus, in the very land where Bruce records that he obtained water from the stomachs of camels, which his companions had slain for the purpose, large armies afterwards marched in safety. Full particulars of the adoption and use of driven wells by the army in Abyssinia are to be found in the reports of Sir Robert Napier, transmitted to the British Parliament and published in their proceedings. In these reports proper credit is accorded to them as an American invention, and their uses and advantages are set forth, and the statement made that by the opportune arrival at Magdala, on pack-mules, of material for two of the wells, pure water was furnished the forces after an enforced abstinence of sixty hours duration.

Mr. S. K. Morrison, of Melbourne, Australia, exhibited in Agricultural Hall apparatus referred to as "Patented Abyssinian Tube Wells and Pumps, with Boring Apparatus," which was evidently a reproduction of the American types furnished for that campaign.

At about the time driven wells were used in Abyssinia the Emperor of the French personally superintended their experimental operation at Buchy, and near Paris, under the direction of the American agents, which met with such

decided success that a number were ordered for the army and for the School of Agriculture. These wells are adapted to supply water to households, farms, and manufactures, and for armies in camp or on the march, emigrants journeying overland, miners, explorers, lumbermen, hunters, etc., and furnish ready means for procuring water in most localities where it would otherwise be practically inaccessible.

Water is procured from the sand and gravel strata of the soil, and in many localities one or more layers of clay are passed through before the most desirable quality of water is reached. The depth is to a great extent governed by the quantity, quality, and temperature required, and varies from 30 to 100 feet. The deepest wells furnish the coolest water, and intermediate ones a different quality. Water is usually found from 10 to 25 feet below the surface, but a majority of wells are over 40 feet deep, and in all cases the water rises to a level with the surface water.

For manufacturing purposes, where large quantities of water are required, a number of two-inch tubes (the usual size) are connected to one larger main pipe, to which a steam-pump is attached. From two to twenty tubes have been so connected. The tubes are driven by a falling weight, like a pile-driver, weighing from 50 to 150 pounds.

Some trouble was at one time experienced by the points becoming corroded and stopping the inlet passages, in which case it was necessary only to withdraw the tubes, attach new points, and replace tubes; but with the points now used such stoppages do not occur, and wells in use for several years furnish water as freely as when first driven.

Driven wells are being largely introduced even in the cities of New York and Brooklyn, where the best improved modern systems of water-supply are in use, and have superseded dug wells and cisterns, the result being a saving in cost of the water used that is truly remarkable. Driven wells are in constant operation on the premises of the Western Union Telegraph Company, Whiting Manufacturing Company, Matthew White Malt-House, in a large number of breweries, in the New York Herald and other newspaper establishments, in Hecker's Flouring-Mills, in the Manhattan and a number of other sugar refineries; also in chemical works, mineral water establishments, and a large number of other manufactories. It appears from testimony in a United States, court that the New York Gas-Light Company are making a saving of $8,000 per year in cost of Croton water alone by the use of two gangs of these pumps at the works at the foot of East 21st Street. The low temperature is also of great advantage in washing gas and cooling coke. In Brooklyn driven wells are also largely introduced in various manufactories.

The soil underlying the city of New York consists generally of strata of sand, loam, gravel, and an exceedingly tenacious clay. These layers also vary in thickness and order in different places, there being from one to three layers of clay, each from 6 to 14 feet thick, in the depth of 100 feet. In Brooklyn, in one instance, on Imlay Street, a depth of 100 feet of clay was passed through, when beneath a good supply was reached which rose to within 8 feet of the surface.

Most of the wells mentioned are used steadily ten hours per day, some for twenty-four hours each day, for six days in the week, while others are in constant operation,—and after months, and in some cases years of use, the supply continues undiminished.

The reliability of driven wells for continuous supply has led to their extensive adoption by villages and small cities for fire purposes, etc., and it is possible that some of the larger cities may find it advantageous to utilize this cheap and efficient means of increasing their water-supply, and save the expense of extending their aqueduct and reservoir systems.

The driven well, in all places where it is applicable, will probably supersede the old methods of well-making, for in addition to its simplicity and convenience it avoids the necessity of using surface water, and contaminations of drainage, vermin, etc., to which open wells are subject, and draws its supplies from either of the cooler and purer strata usually found deeper in the earth, each having distinctive qualities, and from which any desired selection may be made, and the others excluded.

Hydraulic Presses.

Mr. Morane, Jr., Paris, France, exhibited a horizontal hydraulic press for use in the manufacture of candles. The material to be operated upon was to be placed in the press in bags, which were arranged between plates heated by steam introduced through telescopic tubes. A small hydraulic ram was provided to retract the main ram. All the parts, including the accompanying pumps, were well designed and carefully constructed.

Messrs. John Robertson & Co., Brooklyn, N.Y., exhibited a medium-sized, excellently finished hydraulic press, with pumps, containing some improvements to insure the efficiency of the various details, which could be explained only in connexion with elaborate drawings.

Mr. John F. Taylor, Charleston, South Carolina, exhibited a combined steam and hydraulic cotton-press. The upper platen was stationary, and supported two hydraulic cylinders, each about 22 inches in diameter, which operated the bed through four heavy wrought-iron bars each about 7 inches square. Water under pressure was supplied by two pump-plungers of different sizes, connected directly to inclined steam-cylinders also of different sizes. In operation the pressure was first applied by means of the larger pump-plunger, which was operated by the piston of the smaller cylinder, after which the steam was exhausted from this cylinder to the larger one operating the smaller plunger. The pressure in the latter cylinder was supplemented with live steam when necessary. These presses are used in re-pressing cotton so as to enable it to be stored economically on board vessels, and are in successful and efficient operation in various Southern cities.

Messrs. Bolen, Crane & Co., Newark, New Jersey, exhibited hydraulic presses in which water was admitted under pressure to canvas rubber-coated bags located between stationary and movable plates, arranged alternately one above another. The stationary plates are connected by side rods to a cross-head at the top, carrying a large adjusting screw, and the movable plates are connected by studs, so that all act at the same time on the bed-plate. The bags are connected together for the passage of fluid through a pipe formed by compressing studs on external ears. The bags are made by coating heavy canvas with rubber $\frac{1}{16}$ inch thick, and compressing two pieces of the canvas with the rubber faces together between two frames of iron made entirely without finish, and held together by small bolts. The bags yield sufficiently under a pressure of 50 pounds per square inch to elevate the bed two or three inches. The bags last about a year and cost but little to renew. The largest press in use contains 10 bags, each 20 inches by 20 inches, and yields a total pressure of 100 tons, with a water pressure of but 50 pounds per square inch. The pressure from city water-works is ordinarily sufficient, but may be supplemented by using an ordinary force-pump.

Hydraulic Jacks.

Hydraulic jacks were shown by four exhibitors, the principal exhibit being that of the original inventor of these useful tools, Mr. Richard Dudgeon, of New York. The Dudgeon jack was invented in 1848, and its development at that time involved inconceivable difficulties on account of getting suitable tubes, &c. The usual difficulties were also encountered in its introduction, after which it came into very general use. The receiving valve of the pump is in the lower end of the plunger; the fluid being supplied by grooves in plunger communicating with a cross-opening. The delivery-valve of the pump is located in an inverted position at the bottom, and supported by a spring. To lower the jack the operating handle is reversed, and is so shaped that it will then force the pump-plunger lower than the usual position, open by contact the delivery-valve at the bottom, and at the same time expose in pump-chamber the cross-opening in plunger, previously mentioned, and thereby give the fluid an opportunity to return to the supply-chamber. The exhibit included several forms of the hydraulic jack adapted to various uses, among others a pulling-jack. Specimens of the Dudgeon hydraulic punch were also shown. It much resembles an ordinary screw punch in size and appearance, but the punch proper is carried by a plunger which is separated from the end of the screw above by a fluid. The screw is effectually packed on the threads,

thus forming the pump of a small hydraulic press of great power and remarkable compactness.

Mr. Dudgeon also exhibited his boiler-tube expanding tool, invented in 1867, and now very extensively used. A hollow cylinder, of less diameter than the boiler-tube, and provided with a guide-sleeve, to bear against the tube-sheet, is provided with openings to receive small grooved rollers which rest inside on a central conical mandrel. By inserting the tool into the tube and pressing upon and revolving the mandrel, the rollers expand the tube in the sheet with great facility; the instrument being, in fact, so powerful that care must be employed in its use, and it is not uncommon to see the tube openings themselves expanded by the pressure applied inside the tube.

Water Motors.

The exhibit of turbines was quite large. The desire of the Group to have them thoroughly tested, by utilizing the large elevated tank of the waterfall in connexion with the flume provided for in the plans of the Bureau of Machinery, could not be carried into execution while the co-operation of the foreign members was available. At a late date, however, when, in the opinion of Prof. Reuleaux and others, it was not practicable to make thorough tests in the time available, an arrangement was completed in the Bureau of Machinery to make a series of tests at the expense of the exhibitors, under the charge of Mr. Samuel Webber, a member of another group, whose engagements permitted him to devote his time to the subject. Group XX. co-operated by inviting Mr. Webber to become an associate member; the tests were proceeded with, and, by strenuous efforts, in which two sons of Mr. Webber rendered valuable services, a series of experiments was completed, which appear in the report of Mr. Webber to the Bureau of Machinery, hereto appended.

The experiments served fully the purpose of ascertaining the relative performances of the turbines when tested under similar conditions, but, unfortunately, do not fully answer the original purpose of the Group to obtain results with the great accuracy required in correcting the constants and extending the formula applicable to the subject. Carefully-conducted experiments with turbines then in use are described in the well-known work on Hydraulic Experiments, by Mr James B. Francis, of Lowell, Massachusetts. His formula for the flow of water in rectangular weirs, based on elaborate trials, has been shown by Prof. James Thomson to correspond in form with that determined mathematically, and from the care and discrimination exercised in the various experiments, the methods and deductions have been accepted as a standard.

The brake used at Philadelphia for measuring the power was similar to that employed by Mr. Francis, and operated with perfect satisfaction. A question arises, however, as to the absolute accuracy of the water measurement, as, in the haste to complete the work, precautions observed in the more prominent experiments on the subject were neglected. The water was necessarily admitted to the side of the weir approach, and proper measures were not taken to remove eddies and secure uniform velocity in the direction of the weir, or to protect the openings to the hook gauge-box from the influence of the maximum current. The initial and final curves, angles, areas, &c., of the wheels and of their supply openings were ascertained for most of the turbines, and part of the information is embodied in Mr. Webber's report. The templates of the angles and curves, in the possession of the writer, are available for discussion when the influences on the results, due to variations from the standard method of the nature referred to, shall be settled by experiments on the subject.

The experiments show that turbines are now so perfected as to give the highest efficiency of any hydraulic machine. Mr. Uriah Boyden, of Boston, Massachusetts, is believed to be the first person in the United States who devoted his energies to the improvement of turbines, and his success gave an impetus to investigation and invention on the subject. The results obtained with the Boyden-Fourneyron turbines have never been equalled. Turbines of this kind are now designed and constructed by Mr. Edward Sawyer, of Boston,

Massachusetts, who exhibited drawings of them in the rooms of the American Society of Civil Engineers.

The only turbines exhibited from abroad were in the Canadian Department, some of which were tested, as is shown in the report. Drawings of double turbines, ingeniously arranged, were shown by Mr. A. J. Atterberg, of Hagforsen, Rada, Sweden. Mr. W. Wenström, of Orebro, Sweden, exhibited drawings of a water motor of a type discussed in theoretical works, but not yet introduced in the United States. The construction resembles an undershot wheel adapted to be run under water, if necessary like an ordinary turbine. The water is admitted through a scroll-shaped conduit partially surrounding the wheel, and, entering a certain distance between the vanes, which are turned towards the current, it is finally thrown out by centrifugal force, and escapes through an opening in the case beyond the supply passage,—the path taken by each particle of water resembling two branches of a cycloid. The construction readily admits the location of several wheels, of the same or different widths, on the same shaft, to suit variations of power.

Miscellaneous.

The exhibits of pipes, stop-valves, cocks, beer-engines, soda-water machines, bottling-apparatus, corking-machines, &c., referred to this Group, were all very complete, but involve too much detail to admit of description. The advances made in the manufacture of wrought-iron and brass pipe were quite conspicuous. The National Tube Works, of Boston, Massachusetts, and McKeesport, Pennsylvania, was the first firm in this country to engage in the manufacture of exceptionally large wrought-iron seamless pipes. The firm exhibited wrought-iron pipes of various sizes, from $\frac{1}{8}$-inch to 15 inches in diameter, both thin and thick. At the date of writing, still larger sizes are made by the firm mentioned, and by Messrs. Morris, Tasker, & Co., the well-known manufacturers of Philadelphia, Pennsylvania, and New Castle, Delaware, who had also a very creditable and prominent exhibit.

BLOWING MACHINERY.

The principal exhibit of fan-blowers, exhaust-fans, &c., was that of Mr. B. F. Sturtevant, of Boston, Massachusetts. This manufacturer has made a special study of the mechanical details of blowers, and has systematically conducted a large number of experiments to determine the best proportions for delivering a desired volume at a given pressure, with maximum economy. His illustrated albums are of considerable interest and value, independent of the purpose for which they were designed. Blowers of different proportions are furnished for pressure and volume. The vanes of the fan-wheels are inclined backward, and are secured between cone-shaped discs attached by light braced arms to a steel axle, the journals of which swivel in the supporting brackets, and are provided with approved oiling attachments. The improvements, being chiefly in proportions and matters of detail, would require elaborate drawings for illustration.

A very creditable exhibit of fan-blowers and exhaust-fans was also made by the Exeter Machine Works, of Boston, Massachusetts.

The two principal exhibits of rotary blowers and exhausters were those of Messrs. P. H. & F. M. Roots, of Connersville, Pennsylvania, and of Messrs. Wilbraham Brothers, Philadelphia, Pennsylvania. The peculiarity of the Roots blower is in the shape of the rotary pistons,—all outlines of which are arcs of circles. For each piston a suitable metal centre is secured to the shaft, and is covered with wood, which is readily put in the shape desired. The relative positions of the pistons are maintained by external gearing, which is provided with safety casings. For small-sized blowers, as well as for exhausters, which latter require greater accuracy in fitting, the rotary pistons are constructed of metal and accurately fitted. Suitable adjusting pieces are also provided in the exhausters, by which any reasonable degree of tightness may be obtained. For smaller blowers the pistons are carefully fitted, and the cases provided with recesses, which are filled with a composition containing plaster of Paris, which insures tightness at a reduced expense. Messrs. Wil-

braham Brothers, above mentioned, manufacture the Baker rotary blower. The same arrangement is used as an exhauster and as a pump for fluids. In a case of the shape shown a central finished drum is provided with two vanes or rotary pistons fitting fairly the two ends of the case and the bored semi-cylindrical top. In the bottom are two drums, which run closely together and to the central drum, and to the former motion is imparted opposite that of the latter, and with double its velocity, by external gears (encased to prevent accident). The lower drums are crescent-shaped, as shown, the exteriors being turned and running close to projections on the case. In operation, as each vane of the central drum passes from right to left, air is received at the bottom of the right-hand side of the case, which is forced out of the opening at the left. The opposite vane moves through the opening in each of the lower drums successively, and the latter turn so as alternately to form abutments to prevent escape from the delivery side at the left to the receiving side at the right. The cavities in lower drums are kept free of the vanes, so all necessary fitting can be performed in a lathe. These blowers are run at pressures varying from a few ounces to three pounds per square inch, and have been successfully applied to a large number of purposes, but principally for smelting-furnaces and smitheries.

There were two prominent exhibits of blowing-engines for blast-furnaces. Messrs I. P. Morris & Co., of Philadelphia, Pennsylvania, exhibited one of the type most in favour in the United States, provided with a steam-cylinder 48 inches in diameter and a blowing cylinder 75 inches in diameter, the stroke being 6 feet. The average speed of the engine does not exceed 20 revolutions per minute, and the usual blast pressure is 10 pounds. The cylinders are arranged vertically with the blast-cylinder above the other. The main shaft crosses underneath the main cylinder, and carries at each side heavy fly-wheels, acting also as counter-balance wheels, to which are attached the crank-pins. From the latter connecting-rods are extended upward to a cross-head, attached to the piston-rods between the two cylinders. Steam is distributed by single poppet-valves, each of which is constructed with a cylinder on its top running freely over a stationary piston. In operation each valve-stem first lifts a "pilot" valve, or small valve seated in the top of the main valve, which equilibrate the pressure between the lower side of the main valve and the piston above it, when the pilot-valve comes in contact with the main valve and lifts it quite easily. This arrangement, designed by Mr. A. Wanich, secures the tightness of a single poppet-valve with the ease of operation due to a balanced valve. The engine was very well constructed, and the design and details were carefully worked out.

Mr. P. L. Weimer, of the Weimer Machine Works, Lebanon, Pennsylvania, exhibited a high-speed blowing-engine, with steam and air cylinders respectively 20 and 50 inches in diameter, the stroke being 24 inches. The engine was designed to run regularly at a speed from 75 to 100 revolutions per minute, and had been run on trial at 136 revolutions per minute. The general arrangement of steam-cylinders and connexions was the same as that of the engine previously described. Steam was distributed by a slide-valve operated by a link motion. The principal feature of novelty was the design and arrangement of valves in the blast-cylinder. Many persons, after watching for a time the slow movements of a large blowing-engine of the ordinary type, have expressed surprise that an engine had not been constructed to perform the same work with equal reliability at higher speeds, as similar changes have been successfully accomplished with engines designed to perform other duties. For instance, slow rolling mill engines of the past have been superseded by smaller ones directly connected to run at the full speed of the rolls, and paddle-wheel engines on ocean steamers have been replaced by quicker-acting screw-engines. The difficulty in designing a high speed blowing-engine is to obtain sufficient valve area to admit the air without increasing the waste space so as to produce serious loss of action, which has been successfully overcome by Mr. Weimer. To the ends of the blast-cylinder are attached annular chambers, containing inside the inner shell the delivery valves, which chambers are connected by a casing or jacket forming the delivery-chamber, from which the compressed air is conducted by suitable pipes. Into each end of the cylinder, lengthened by the chamber mentioned, are extended sectors

open at their tops and provided with gratings in their bottoms and sides, the outer diameter of the sectors being a little less than that of the bore of the cylinder. The sectors are connected together at their outer ends, and form the cylinder cover. The openings in the bottoms of the sectors are concentric with the cylinder; those in the sides are arranged vertically, and all have usually a width of $\frac{5}{8}$ of an inch. Each grating is covered inside the cylinder by a gridiron-valve made of a single thickness of leather, which operates between the grating or valve-seat and a guard perforated to correspond with the valve, the distance between the guard and valve-seat being adjusted to give about $\frac{5}{16}$ of an inch lift. The delivery-valves are similarly constructed, being made in short sections and inserted through openings covered by bonnets. By this means all the area necessary for the admission of air at high speeds is obtained. The piston is made with a central disc, provided on either side with cylindrical flanges stiffened by ribs. The ribs, the external flange, and the central boss run into the space between and around the sectors, and reduce the clearance and waste spaces to a minimum. The piston packing is of wood, set out with springs. When engines of this class are run rapidly the compression of the air serves to cushion the reciprocating parts, for which reason the manufacturer expects to obtain higher speeds than are common with other engines.

Transmission of Power.

One of the most instructive exhibits to foreign engineers was the system of transmission of motion in Machinery Hall, and in the various other buildings in which machines in motion were exhibited. The few examples of the American system of transmission at Paris and Vienna in 1867 and 1873, and the subsequent comments in the various foreign journals, had prepared the experts who visited America in 1876 to note carefully the system, as a whole, and its operation, as here for the first time it had been displayed in its fullness at a world's fair. The importance of this branch of engineering calls for a brief historical sketch, and some little explanation of the principles involved. A recent writer on the subject says, "In any large factory the "shafting, with its couplings, pulleys, and other adjuncts, considered as a "machine to transmit motion, is most frequently the largest in the establish- "ment; hence every consideration of economy requires that it should do its "allotted work with the least possible loss of power in the transmission. It "calls for economy in first cost, and economy in use."

The first distinctive feature of the American system is the extended use of belting in place of toothed gear-wheels to transmit motion from the motor to the various lines of shafts, and thence to the machines. In 1841, Prof. Willis, in his *Principles of Mechanism*, says that in London belts were much used on account of their silent and quiet action, but that in American factories their use had greatly extended. "In Great Britain the motion is conveyed from "the first moving power to the different buildings and apartments of a "factory by means of long shafts and toothed wheels, but in America by "large belts moving rapidly, of the width of 12 or 15 inches, according to the "force they have to exert." This really sounds the key-note to the American system, which has extended to the almost entire abolition of toothed wheels for transmission except at low speeds and on the ground-floor, and the substitution of belts of even in many cases four feet in width; one belt exhibited and hereafter referred to was five feet in width. That the subject of toothed wheel transmission has not been neglected in this general preference for belts was pleasingly illustrated by Mr. Corliss, who furnished the shafts and bevel-wheels which transmitted the motion of his large engine to the various points from which the belts took it to the line shafts. The construction of the bevel-wheels, planed true on each tooth by his planing-gear-cutter, the firmness and rigidity of their ground fastenings, coupled with their high speed for gearing of that kind, furnished a notable example of the most approved gear-wheel transmission on a large scale,—working so well and silently as to be unknown to many who walked daily over the floor that concealed them, and familiar only to those who traced out the system from the engine. The line shafting running in bearings attached to the beams overhead was at all times in full

sight, and could not fail to attract attention from its extent and smooth running. This part of the exhibit was American in every particular. In Machinery Hall there were eight main lines of shafting; the largest diameter being 6 inches at the head-shafts, and decreasing to 3 inches as the smallest diameter, the total length of each line being about 623 feet. The shafting erected by Messrs. William Sellers & Co., of Philadelphia, formed much the largest part of the entire exhibit in Machinery Hall, inasmuch as they shafted the half of the main room east of the transept. They also erected the shafting in Brewers' Hall, and put up many of the private lines, in all furnishing about 3,500 feet. When bids were asked for by the Board of Finance for this work, that of William Sellers & Co. was the lowest, but as other makers of shafting desired space to exhibit lines in motion in Machinery Hall, they relinquished one-half of this building to them. All the shafts were of wrought-iron,—each line of 623 feet being collared at one end only, and held so securely by couplings as to be practically, as far as strength was concerned, an unbroken bar of that length. The couplings used were of the adjustable kinds, and the hangers of the ball-and-socket pattern. The speed of all lines used to drive iron-working machines and the like was 120 revolutions per minute, while that of those driving wood-working machines was 240 revolutions.

The American preference for high-speeded belted shafts has been the growth of years. In mills built thirty years ago, examples of toothed wheel transmission, so generally employed in Great Britain, were common, but belted mills were growing in favour. Since then many of the former have been remodelled on the new plan. The essential features of American shafting, as a piece of mechanism in its entirety, originated with the house of William Sellers & Co., who were the first persons to engage in it as a distinct branch of manufacture, and to establish a fixed scale of prices for each and all of the various items which go to make up the transmissive equipment of any establishment. This scale of prices was brought about by the introduction of the first really practicable adjustable coupling, which enabled them to abandon the hook or open-sided hanger, in use with the plate-coupling, for a lighter but stronger form of double-braced hanger.

To Mr. Edward Bancroft, the former senior partner of the present house of William Sellers & Co., is due the introduction of the swivel principle of box or bearing in line-hangers. Later, his improved ball-and-socket hanger took its place, to which was added the principle of adjustment for alignment. This form of hanger was a marked improvement, and has now come into general use. The spherical supports of the long bearing insure absolute uniformity of pressure over the lubricated surface, and diminish the frictional resistance. Added to this, a matter of no little moment, the cost of erection is reduced to a minimum—there being no necessity of any special care in setting the feet of the hangers, as all required adjustments to line are either possible or self-controlled. This principle of hanger with well-fitted plate-coupling contributed to make up the best type of shafting, apart from considerations of first cost and ease of repairs afterwards. The plate-coupling required that each half be securely fitted to the end of the shaft to which it belonged, that the pairs, to be afterwards bolted together, be true with the axis of the shaft, and this accuracy was represented in the first cost of the work. Couplings of this kind were fitted with care, and then fixed in place with powerful screw-presses, rendering the attachment of pulleys expensive and troublesome. Their use also involved the use of the open-sided hook hangers in place of the double braced hangers, previously referred to. Attempts had been made to use sleeve-couplings, but in 1856 William Sellers & Co. introduced what they call their "double cone vice-coupling." This holds the shaft centrally within an external sleeve, regardless of slight differences in the size of shafts, and as the clamping cones within the outer sleeve are drawn towards each other by the through bolts, a uniformity of pressure is obtained on each shaft end. The use of this coupling did away entirely with the expensive fitting necessary in the use of the plate-coupling, and rendered possible the production of standard shafts of given lengths, splined on the ends for keys, but requiring no special care in the accuracy of size at the ends; and the introduction of this coupling, and the improvement in the form of the ball-and-socket hanger, already

alluded to, rendered possible for the first time the manufacture of shafting with interchangeable parts, and the production of a price-list for these parts, in place of the old plan of selling all such work by the pound. This was immediately followed by an extensive series of experiments on the proper proportions of pulleys or band-wheels for the various uses to which they are applied, and the remodelling of all the minor accessories of shafting, to admit of graded prices per piece. Under the old system, or want of system, the purchaser was ignorant of the total cost until the completion of the work; whereas under the new system it is always possible to ascertain the cost before the order is given to execute the work. The pulleys made by William Sellers & Co. have always been with straight arms, instead of the crooked or **S** arms still in use by many makers. It is claimed that the straight-armed pulleys can be made with the least possible metal to obtain a given strength, that they are best suited to transmit the peculiar strains brought to bear upon them, and are at the same time pleasing to the eye. The rapid growth of manufactories in America during the past quarter of a century has developed a great market for shafting, while improvements in methods have reduced the cost to the consumer. It is not possible to arrive at a correct estimate of the amount of shafting made in the country, but we are informed that, during years of business prosperity, the newly-erected cotton- and woollen-mills alone necessitated so large a production that often the firm of William Sellers & Co. had as much as 10 miles of shafting under construction at one time. Their market is now extending over a large part of the world, and their models have not only been introduced into the leading technical schools of Europe, but have been freely copied at home.

Messrs. Jones & Laughlins, of the American Iron Works, Pittsburg, Pennsylvania, included in their extensive exhibit cold-rolled shafting, couplings, hangers, pulleys, etc. This firm uses the Collins patent coupling. A central sleeve made in halves is bored slightly less than the diameter of the shaft, and coned externally in opposite directions at the centre, over which the rings, correspondingly coned internally, are fitted and set up by nuts on the ends of the sleeve, thereby maintaining the connected shafts rigidly in line. This coupling may be erected with great facility, and is readily taken apart to permit changes of pulleys, etc. The hangers employed have a long journal to receive the shaft, and the boxes at the top and bottom have spherical bosses turned upon them, to which are fitted the ends of large adjusting screws.

The cold-rolled shafting exhibited has a highly-polished surface, and is remarkably straight and uniform in size. The cold rolling condenses the metal, and appears to increase the strength in every essential particular. From tests made by Major Wade, of the United States Ordnance Department, in 1860, it appears that similar bars of puddled and charcoal bloom iron, all rolled hot in the process of manufacture, were increased in strength by cold rolling by Lauth's patent process, under test with various kinds of strain, as follows: Transverse strain for permanent set, increase in strength 162½ per cent.; torsional strain to produce permanent set, increase 130 per cent.; compressional strains to produce permanent set, for test piece with length of 11 diameters, increase 64 per cent.; for length of 2½ diameters, increase 161½ per cent.; tensional strains to produce permanent set, increase 95 per cent.; ultimate strength under tension, increase 72 per cent.; hardness, increase 50 per cent. Sir William Fairbarn found an increase of 50½ per cent., comparing ordinary bars of given size with similar bars reduced in size by cold rolling. A similar series of trials made by the Franklin Institute, Philadelphia, showed an increase of ultimate strength for the cold-rolled shafting of 61 per cent. in tension, and 97 per cent. in compression. The manufacturers claim that cold-rolled shafting has 75 per cent. more effective strength than the same sizes of turned iron, and report that they had about 4,300 lineal feet in motion at the Exhibition.

The cold-rolled shafting is used by locomotive and other engine builders, and by pump manufacturers for piston-rods, pump-plungers, &c., without turning, except to make connexions. It is also used to make pins for bridges. Cold-rolled iron is also used in preference to steel for the finger-bar and knife-backs of reapers and mowers, and for other special purposes.

Messrs. Jones & Laughlins report an annual production of 4,000 tons of cold-rolled shafting, and 1,000 tons of the special shapes last above-mentioned.

Mr. George V. Cresson, of the Philadelphia Shafting Works, had an extensive exhibit of shafting, pulleys and hangers, which were arranged in a novel and effective manner. The principal peculiarity in construction was the coupling cast in one piece, provided with an angular recess, which, in connexion with a longitudinal slit, forms two internal clamps at each end, which are set out against the shaft either by longitudinal tapering screws, or, when the coupling is applied to a pulley hub, by set-screws arranged radially. The clamps are also divided by a transverse slit into two parts, so that each end of the shaft is grasped separately, permitting reasonable variations in size. The operation of this simple device will be readily understood without further description.

Messrs. Pool, Hunt, & Co. had also a very creditable exhibit of shafting and pulleys, the castings of the larger pulleys being particularly smooth and regular.

Messrs. Pusey, Jones, & Co., of Wilmington, Delaware, included in an interesting exhibit, relating to steam and paper-mill machinery, the expanding pulley. The several arms carry separate segments of the rim, and are shifted radially in suitable guide-sockets in the hub by radial screws provided with bevel-gear connexions to the train of gear and the hand-wheel. These pulleys are principally used for driving the drying cylinders and the press, couch, and calendar rolls of paper machinery, and in other places where frequent small changes of speed are required, and have come into general use for such purposes.

Messrs. Stow & Burnham, of Philadelphia, exhibited the Stow flexible shaft, with tools and machines for operating in connexion therewith. The shaft is made up of a series of coils of steel wire wound hard upon each other, each alternate layer running in an opposite direction, and the number of wires in different layers varying according to the work the shaft is adapted to. On being brought to size, about one and a half inches at each end of the shaft is brazed solid, and to the solid ends fittings are attached, one to receive the tools to be operated, the other to receive the operating pulley, which in turn receives its power from a round belt. Surrounding the shaft proper is a case consisting of a single coil of iron wire, the internal diameter of which fits loosely on the outside of the shaft and is covered with some flexible material,—leather preferably,—over which, at each end, a ferule is fastened, and to the ferule, at the end opposite the frame which carries the pulley, is screwed the hand-piece.

Motion is usually transmitted to the pulley on the shaft by a flexible cord running over leading pulleys, some of which have wood screw shanks, which can be screwed into any of the wood-work of the building, while others are provided with hooks and may be " triced up " to any point. The shaft and attachments enable power to be transmitted readily to all positions and applied in any desired direction. Augers, drills, and metal and steam-working tools of various kinds, are provided for attachment to the shaft, the speed being reduced by gearing for the heavier operations.

Excellent wooden pulleys were exhibited by Messrs. A. B. Cook & Co., of Erie, Pennsylvania, and there were many ingenious and valuable devices for use in connexion with the transmission of power, involving too much detail for full presentation.

Belting.

The advantages to be derived from the use of belting for the transmission of power, compared with gear-wheels, particularly in respect to original cost, facility of adaptation, immunity from accident, and reduction of jar and noise, are now well understood, at least in the United States, and even here changes of direction for which bevel-gears were, in certain quarters, considered indispensable not many years since, are now accomplished with belting. A notable instance is in flouring-mills, where " half-twist " belts are run from pulleys on a horizontal shaft directly to pulleys on the vertical mill spindles. Moreover, in

whatever the direction belting be run, the motion can at will be stopped, and applied with facility and without jar. For this purpose belt-shifters, with loose pulleys, are adapted for narrow belts on parallel shafts; for wider belts adjustable tightening pulleys are employed, and they may also be used with belts, running in any direction, by providing in some cases suitable boxes or channels to form guides as the belt is brought into action.

The rules of different writers for proportioning the more important belts in a manufactory give results widely differing. Mr. J. H. Cooper during a number of years (1869 *et seq.*) collected, and contributed to the *Journal of the Franklin Institute* particulars as to the power transmitted by large numbers of belts of different sizes, from which it appears that there is no uniformity in the practice on the subject.

The strength of different portions of a first-class oak-tanned hide, adapted for making belts, is set forth in tabular form hereafter.

English belting of different widths, tested by Mr. Kirkaldy, showed an average tensile strength of 842 pounds per inch of width of single belting, and 1126·6 pounds for double belting, corresponding to a relative strength of 1 to 1·34. (Mr. D. K. Clark's *Manual*, p. 680.)

An article in the *Journal of the Franklin Institute* for January 1868, by the editor, Professor Henry Morton, gives the following results of tests made by Mr. Henry R. Towne of belts 3 inches wide and 2·19 inches thick:—

Ultimate Tensile Strength.	Per Inch of Width.	Per Square Inch of Section.
	lbs.	lbs.
At lacings - - -	210	958
At splices or laps - -	382	1,744
Of solid portions - -	675	3,086

The ends of belts, in which lacing holes were punched, were usually found to be weaker than the lacings, and the strength of new and partially-used belts was practically identical. It was found as the average result of 180 experiments with 3-inch belts, under tensions varying from 7 to 110 pounds per inch of width, that on cast-iron pulleys and for 180° are of contact the sliding tension was 6·294 times the slack tension and the co-efficient of friction 0·5833. To provide for contingencies which might arise from various causes, such as moisture in the atmosphere, the interposition of a stratum of air between the belt and pulley at high velocities, &c., Professor Morton adopts only $\frac{6}{10}$ of 6·294, or 3·776, as the maximum practical value, giving a friction co-efficient of 0·423. These values are about one-half greater than those of M. Morin.

Professor Morton calculates the maximum working strain, per inch of width, transmitted by belts having a working strength of $66\frac{2}{3}$ pounds, per inch of width, by means of the following formula, deduced from Rankine's formula: (*Applied Mechanics.*)

$$W = 66\tfrac{2}{3}\,(1 - 10^{-0{\cdot}003206\,a}.)$$

W = the working stress transmitted per inch of width, in pounds.
a = the arc of contact in degrees.

Upon the basis of Mr. Towne's experiments, as discussed by Professor Morton, Mr. D. K. Clark, in his *Manual*, p. 750, presents a table showing the driving-power of leather belting ·22 inch thick, per inch of width, for arcs of contact from 90° to 270°, together with the maximum transmitted stresses and other information relating to the subject, which is so complete that it is presented (with slight changes in the headings only) in preference to formulæ the writer had at an earlier date prepared on the subject. The maximum transmitted working stresses calculated by Professor Morton by means of the preceding formula are given in column 2. The sum of the tensions in column 6 was calculated, in each case, by adding to the transmitted stress in column 2 twice the difference between it and $66\frac{2}{3}$. The last column gives the resultant stress by the parallelogram of forces, caused by the tensions of the belt on the bearings of the shaft.

Driving-power of Leather Belts.

Maximum working strain, $66\frac{2}{3}$ pounds per inch of width, single thickness.

1.	2.	3.	4.	5.	6.	7.
Arc of Contact.	Maximum working stress transmitted per inch of width.	Power transmitted per inch of width. At a Velocity of Belt of 1 foot per second.	Power transmitted per inch of width. Per foot of diameter of Pulley, for each revolution per minute.		Sum of the Tensions on both sides of Belt per inch of width.	Resultant pressure on the Journals per inch of width of Belt.
Degrees.	Pounds.	Horse-power.	Horse-power.	Foot-lbs.	Pounds.	Pounds.
90	32·33	·059	·00308	102	101·00	71·42
100	34·80	·063	·00331	109	98·53	75·47
110	37·07	·067	·00353	116	96·24	78·85
120	39·18	·071	·00373	123	94·15	81·53
135	42·06	·076	·00400	132	91·27	84·32
150	44·64	·081	·00425	140	88·69	85·67
180	49·01	·089	·00467	154	84·32	84·32
210	52·52	·095	·00500	165	80·81	78·05
240	55·33	·100	·00527	174	78·00	67·59
270	57·58	·105	·00548	181	75·75	53·56

The table, being based on a maximum strain of $66\frac{2}{3}$ pounds per inch of width, provides a factor of safety of 3, at the laced ends of belt, as may be seen by examining the results of the experiments previously given. For belts cemented and riveted in place, as is often done, particularly when a tightening pulley is employed, the quantities in the table can be increased one-half, according to the experiments, and leave a factor of safety at the laps of $3\frac{8}{10}$, and for double belting the quantities can be more than doubled with safety, when the ends are cemented and riveted. An examination of Mr. Cooper's precedents shows that the quantities in the table fairly represent the average practice with large single belts, and that the average practice for double belts would be well represented by multiplying the tabular quantities by $1\frac{1}{2}$. Instances are, however, reported of single belts transmitting strains as high as 136 pounds per inch of width, so that the belts were strained on the working side to 164 pounds or upward per inch of width. It will be seen that such exceptional cases are simply examples of working with a reduced factor of safety, as is common with other mechanism. The power which a belt will transmit with a given tension is varied by the relative positions of the pulleys. When one is nearly over the other the pressure on the lower one is reduced by the weight of the belt, and it may be necessary to use a tightening pulley, particularly when the lower pulley is the smaller.

In proportioning the ordinary narrow belts for use in a manufactory, it is usually considered that one horse-power will be transmitted by a belt one inch wide, running at the rate of 1,000 feet per minute, and proportional power for other widths and speeds. Another rule is, that a belt with a section of $\frac{1}{10}$ of a square inch will also transmit one horse-power at the speed named. The strain on belting $\frac{2}{10}$ of an inch thick will be the same by either of these rules, and will equal 33 pounds per inch of width, and 165 pounds per square inch of section.

It will be convenient to recollect that any good belt will safely transmit, with ordinary arcs of contact, 50 pounds per inch of width, and that the safe working strain of gear wheels is considered to be 400 pounds per inch of width.

It has been ascertained by trial that a belt will transmit about 30 per cent. more power, with a given tension, when the grain or smooth side of the leather is in contact with the pulley than when the flesh side is turned inward. The leather is also less liable to crack, as the structure on the flesh side is less dense and the fibres more extensible. The adhesion of belts is greater on polished than on rough pulleys, and is about 50 per cent. greater on a leather-covered pulley than on a polished iron pulley. Large pulleys and drums may be covered with narrow strips of leather, or with a longer strip wound spirally. Pulley-covers are manufactured in strips of the required width, and

reduced to uniform thickness by machinery. Belts should be kept soft and pliable by applying tallow occasionally, and neat's-foot or liver oil, with a little rosin when they become hard and dried. A new belt will often work better after a good greasing.

The principal distinguishing features of the manufacture of leather belting, in connexion with some historical references, are concisely expressed in the following extract.*

"When belts were first used as a means of transmitting power, leather was selected as the most suitable material. In those days mill-men and others using belts went into the market and purchased ordinary sole leather, from which, without the aid of any of the mechanical appliances now in use in the business, they made their own belts, and very poor belts they were.

"Some forty years ago, Mr. William Kumble, late of the city of New York, —having noticed the growing popularity of belting, notwithstanding the very imperfect method of manufacture then in vogue, or, to speak more correctly, the entire absence of method, and being fully convinced that, if properly made, it would soon supersede the then existing means of transmitting power,— determined to make the manufacture of leather belting a specialty, and we believe he was the first to enter upon it as a business. Before this, little or no attention had been paid to the cutting or stretching of belts. A side of leather was simply cut in strips of the required width, reference being had only to securing the greatest number of feet, without considering the texture of the material, or its natural tendency to stretch unevenly.

"Mr. Kumble's idea was to select his leather with special reference to the making of belts (to so treat it as to render it softer and more pliable than ordinary sole leather), and to use only the best parts of the hide. He also paid attention to stretching the strips that when placed upon the pulleys they would draw evenly.

"But since these early days the methods of manufacture of belting have greatly improved. The prime requisites of a leather belt are strength, flexibility, and elasticity, and to secure these it is essentially necessary that the best quality of hides should be used. Hides suitable for the manufacture of leather belting can only be obtained from thrifty steers that have attained their full growth and have not been worked,—in a word, prime beef cattle. They must be free from blemish, such as brands, cuts, and scores. Thus the preparation of belt leather really commences in the selection of the green hides. The hides are tanned whole.† Only pure oak-tanned leather will make a perfect band, and the most careful attention must be paid to the cleanliness of the vats and the purity of the liquors.

"Careful manufacturers use scarcely one-third of the area of a hide for belting; all that portion from the horns to the shoulders and all the skirts are waste. From the remaining portion strips are cut lengthwise the hide. These are stretched by powerful machinery and retained at the utmost tension they will stand without injuring the fibre. These pieces are jointed and secured so as to present an even surface to the pulley, and the belt runs as though it was one piece.

"The most perfect belt, especially where great power is to be conveyed, is two-ply. The parts are so lapped that the joints on one side are equidistant from the joints on the other side. The result is a band of immense strength, and perfect in its drawing lines.

"The length of life of a well-made and properly cared-for leather belt has not yet been determined, but we know that there are leather belts still doing daily duty that have been in constant use for upwards of thirty years, and belts made thirty years ago were not the perfect articles now manufactured."

The value of a leather belt depends greatly upon the discrimination employed in cutting the strips from the tanned hide and in combining them to secure uniformity of stretch so that the belt will run straight. The results of trials of the strength of the best portion of the hide are shown in the following

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* From the *Pictorial Album of American Industry*.

† This is not true at the present day, as manufacturers with proper facilities tan the centre of the hide used for belting separately, and the rejected portions are tanned by cheaper methods for shoe work.

table, and were derived from separate tests of 48 pieces, cut from a side of leather, each 11¾ inches long and 2 inches wide, which are shown in relative position in the table, the top pieces being at the centre of the hide, and each piece marked with its ultimate stretch in pounds, elongation in fractions of an inch, and the weight of the piece in ounces and drachms.

2,000	¼	3	2,050	3–16	3·1	2,150	3–16	3·2	2,175	¼	3·3
1,400	9–32	2·12	2,000	¼	3	2,625	3–16	3·4	2,325	7–32	3·4
2,000	¼	2·11	2,075	3–16	3·1	2,375	7–32	3·4	2,175	7–32	3·5
2,075	¼	2·12	2,700	7–32	3·3	2,600	7–32	3·4	2,275	5–32	3·7
2,450	¼	2·13	3,025	9–32	3·7	2,575	11–32	3·8	2,225	7–32	3·10
2,475	¼	3	2,975	5–16	3·6	3,200	9–32	3·10	2,175	⅜	3·10
2,575	11–32	3·2	2,875	9–32	3·7	3,475	11–32	3·13	1,850	11–32	3·11
2,675	11–32	3·2	3,075	11–32	3·8	3,450	9–32	4	1,950	½	3·11
2,650	⅜	3·2	2,900	9–32	3·6	3,150	3–16	3·15	2,225	¼	3·10
2,800	¼	3·1	3,050	5–16	3·6	2,850	¼	3·13	2,275	3–16	3·7
2,700	¼	3	3,150	7–32	3·5	3,000	3–16	3·10	2,600	¼	3·5
2,650	¼	2·13	3,000	7–32	3·4	3,400	¼	3·6	2,550	¼	3·4

When cheaper belts are required the alternate pieces are reversed, and the ends cut from the shoulder joined together in a long lap and the opposite ends by a short one, so that the belt consists of longer pieces than before, with long and short laps alternating. It is evident that pieces may be cut in such locations that their two sides will not stretch alike, and the strength of the belt be reduced to that of the weaker portions of the hide; so also there may be a number of intermediate cuts. In this manner the cost of belting may be varied by as much as 15 to 20 per cent. when using the same stock. It should, however, be observed that pieces which will stretch differently on the two sides may, to a certain extent, be joined so that the greater stretch will take place alternately on opposite sides of the belt, and thereby prevent important deviations from a straight line when the belt is in motion. Large quantities of the cheaper belting are used, especially where ample pulley-surface can be obtained for the power transmitted.

In making double belts, the pieces may be so selected and combined as to produce the best results under severe strains, and instances are recorded where a single belt, which in practice proved to be of insufficient strength, was made to do the work satisfactorily by reinforcing the outer edges, only, with narrow belts.

Belts are made from leather tanned by various processes. A considerable number were shown made from hemlock-tanned leather and some from Union leather, or that tanned with a mixture of hemlock and oak bark, in the proportion of about 10 to 1. Some of these belts had been coloured and buffed to imitate oak leather, and it is claimed that all such belts lack endurance compared with those made from well-filled oak-tanned leather.

Specimens of belts made with chemically-tanned leather were exhibited, but did not appear well calculated to resist moisture. It is a question whether leather which is porous to a certain extent may not, in many locations, get well filled with the grease and shop-dust which accumulate on all belts, and thereby the advantages of original flexibility be secured with a satisfactory measure of durability.

The largest belt ever constructed was exhibited by Messrs. J. B. Hoyt & Co., of New York. It was made for Messrs. Jessup & Moore's Augustine (paper) Mill, Wilmington, Delaware, and was 5 feet in width, 186½ feet in length, and weighed 2,212 pounds. Messrs. Hoyt & Co. use leather made from selected hides, adapted for belting, tanned with oak bark, in their own tanneries, at Pawpaw, West Virginia; and Everett and Rays Hill, Pennsylvania; at Chattanooga, Tennessee, and at Flintstone and Cumberland, Maryland. They manufacture short lap-belting only, unless long lap is ordered; but, as tanners, sell leather to other belting firms, some of whom have special methods of finish by which their products are distinguished. Other firms have facilities of a similar nature, though some are embarrassed by location in getting a full supply of oak bark.

So many of the manufacturers of leather belting employ to a great extent similar workmanship, and the same methods of manufacture to similar qualities of leather, that it is unfortunate, on account of space, that special features can only be referred to.

There are some 70 to 80 manufacturers of leather belting in the country, and the value of the sales annually is estimated at from $2,500,000 to $3,000,000.

The large belts used to drive the main line of shafting were furnished by different exhibitors, and all, without exception, appeared to excellent advantage. A few embodied peculiarities in construction used by the manufacturer for special locations. The list is as follows: Shaft No. 1, G. S. Fales; No. 2, Page Belting Company, Concord, New Hampshire; No. 3, Alexander Bros., Philadelphia, Pennsylvania (one of their patent double belts); No. 4., Charles A. Schieren, New York; No. 5, Josiah Gates & Son, Lowell, Massachusetts (belt secured with pegs, well adapted for damp locations); No. 6, Anton Heim, New York (belt fastened with cement only); No. 7, J. B. Hoyt & Co., New York; No. 8, A. Burgess & Son, Providence, Rhode Island; Annex No. 3, Thomas Rorer, Philadelphia, Pennsylvania (combined leather and canvas).

Messrs. P. Jewell & Son, Hartford, Connecticut, who manufacture large quantities of leather belting, showed, in connexion with their exhibit, belt-laces tipped with metal, like shoe-strings, the advantages of which those having practice in a large establishment will not be slow to realize.

Messrs. Chatfield, Underwood, & Co. of New York, exhibited angular belting, consisting of a narrow double belt, to which was secured at close intervals leather blocks of V-shape, adapted to run in the V-groove of a pulley. With this belting additional adhesion is obtained with less initial tension, and unusual changes of direction can be made with great facility.

Rubber belts were exhibited by the Gutta-Percha & Rubber Manufacturing Company, and by the New York Belting and Packing Company. The first company had a belt in use in the saw-mill; the latter furnished the belt driving the west shaft in the Hydraulic Annex, which was used much harder than any other running at the Exhibition, the power taken from the shaft being considerably greater than was at first anticipated.

The Messrs. Crane Bros., of Westfield, Massachusetts, exhibited Japanese paper belting. One of moderate width was running in Machinery Hall, and remained in good condition throughout the Exhibition.

In this connexion should also be mentioned a fine exhibit, by the firm of John A. Roebling's Sons, of Trenton, New Jersey, which included cables adapted for rope transmission, and iron, steel, and copper wire and wire rope for all purposes. Many improvements have been made by this firm in the manufacture of wire. The lengths of single pieces have been much increased, and particular pains taken to secure uniformity in the product. A small section of one of the great cables for the East River bridge, designed by the elder Roebling, attracted much attention. It contained 6,000 No. 7 galvanized cast-steel wires, with an estimated ultimate strength of 22,300,000 pounds.

There were three exhibits of leather belting from Belgium (including samples of hair belting), one from Norway, two from the Netherlands (including samples of hair belting and raw-hide), and one from Russia. The samples were not extensive, but the leather was well filled and the belting very well finished.

Mr. B. Godfredson, of Copenhagen, Denmark, exhibited a number of articles made from a composition of leather scraps, rubber, &c. A belt of this material, $2\frac{1}{2}$ inches wide and $\frac{10}{100}$ inches thick, which contained an insertion of canvas, was quite pliable, and showed on trial an ultimate tensile strength of 2,250 pounds.

Mr. Bruno Hofwark, of St. Petersburg, Russia, exhibited wire belting which was quite a novelty and well worthy of attention. Wire about $\frac{1}{16}$ inch in diameter was wound in link-shape around two larger cross-wires, forming broad, short links, which were joined together by the cross-wires. The belts were to be used on leather-covered pulleys, and were stronger than leather belting.

The Ewart Manufacturing Company, Chicago, Illinois, exhibited chains for transmitting power, made up of open detachable links, one end of each being formed into a hook, the other being cylindrical, to connect with a hook on a similar link; in which way a sufficient number of links are connected together to make up the length desired. The links couple only in one position, and the backs of the hooks being run to the pulleys they are not liable to become

detached. The chain transmits motion positively in connexion with wheels toothed to engage with the links, and is readily adaptable for a great variety of uses. Special attachments are formed on links for the connexion of arms, buckets, slats, rollers, or the like, to adapt the chain for conveying grain, ores, straw, saw-dust, &c.

Several hoisting and conveying machines were exhibited. In that of Nicholas Liarsky Smelensk, Russia, carriages were run on elevated removeable rails, provided with suitable supports. All the parts were portable, and the details well designed to secure facility both in erection and operation.

In the plan exhibited by the United States Hoisting & Conveying Company, of New York, a wire rope is stretched over the place where the goods or minerals are to be handled, on which runs a two-wheeled carriage for transporting the load. The operating-rope is carried from the motive-power around a pulley near the end of the supporting wire rope, and, passing through a pulley on one end of the carriage, is attached to the other end, and receives between the two points of support a pulley carrying a hook on its top end and a bucket below. In operation the carriage locks itself fast to a chock secured to the supporting-rope at the loading-point, thereby disengaging the hook on the block carrying the bucket below, so that by slacking the hoisting-rope the bucket is lowered to be filled, and upon raising it to the carriage, it hooks itself fast thereto and releases the carriage from the chock on the rope, when, by slacking the hauling line again, the carriage runs out on the rope by gravity, and at any desired point the load may be dumped by simply checking its velocity. Sometimes, however, another chock is secured to the rope and the carriage provided with hooks and attachments, whereby the load may be lowered at that point and the bucket raised into position again before the carrriage is hauled back. All operations are performed by the engineer by stopping, slacking, and reversing the operating rope at the proper time. This apparatus has produced great saving to railroad contractors, coal-dealers, gas-works, &c., and in different forms its introduction for various purposes is being rapidly extended.

Elevators.

In most of the elevators exhibited the car was supported by wire ropes, which were operated in many cases by special engines attached to the winding-drums. In the engines for this purpose at the Exhibition, the main valves were made with little or no lap, and set without lead, and the engines were reversed by simultaneously reversing the currents in the main steam and exhaust connexions, in the same way the currents are reversed to the ends of a steam-cylinder. In other cases double ports, controlled by reversing valves, are run from each end of the cylinder. Those on one side lead directly to the nearest ends of the main valve, and are used for raising the load, and those on the other side cross each other and lead to the farther ends of the main valve, and are used for lowering the load. The ordinary link motion is also frequently employed with simple slide valves.

Messrs. Otis Bros. & Co., New York, use vertical engines, piston main valves, disk reversing valves, and rack-and-pawl safety-attachments. As an additional safety apparatus, the counter-balance rope is wound on a drum at the top of the building, which is held fast by a brake, released by a centrifugal governor, when in case of breakage speed becomes excessive.

Messrs. Stokes & Parrish, Philadelphia, Pennsylvania, and the Crane Bros. Manufacturing Company, Chicago, Illinois, use slide-valves, with covers over them, to receive steam pressure in the chest, and to permit the reversal of currents between the centre and ends of the valve proper. In addition to racks and pawls, duplicate ropes are provided, which are run ordinarily under very light strain.

Messrs. Andrews & Bro., New York, use for their elevators a pair of their oscillating engines, previously described, the shaft of which runs directly through the main drum, and carries on an eccentric an inner spur-wheel which does not revolve, but is shifted bodily in a circle by the eccentric, rotation being prevented by four stationary guide-rollers in circular openings in the wheel. The teeth of the spur-wheel engage with the internal gear of a wheel attached to the main drum, the result being that for one revolution of the inner

wheel the outer wheel is advanced the difference in the number of teeth, of the two, or four teeth in the case in question. The inner wheel is duplicated, and operated by an eccentric set opposite the other to equalize the strains. The guide-rollers are attached to disks with separate hubs or bosses secured to the frame, on which bosses the winding-drum revolves. The apparatus attains reduction of speed in a remarkably compact form, and so many teeth are in contact and other wearing surfaces so large, that wear should not be excessive. The main ropes of the elevator run in V-grooves in the engine-drum, and adhesion is maintained by the counter-balance wheels. A separate rope is moved simultaneously with the main lifting-ropes, the office of which is in case of accident to the main ropes to simply hold up wedges in suitable strong jaws inclosing the guides, the effect being that when the car moves down upon the wedges the latter are at once tightened between the guides and rollers in the jaws, and prevent the car from descending farther. The firm fearlessly cut away the main rope at any point desired, to show the positive action of the safety-apparatus. With the usual racks and pawls the springs sometimes fail to act with sufficient power, when a break takes place in the rope back at the engine, so that there is considerable rope to be "overhauled" before the pawls can be shot into the racks.

In the exhibit of Joseph Goldmark, New York, links are carried up in inclosed guides, which, in case the car falls, double up and catch fast, so as to stop the descent.

Messrs. Tatham Bros., New York, showed a safety-attachment for elevators, in which side-arms and a connecting cross-bar are kept in vibration as the car moves by rollers in sinuous grooves in the guides. If the speed becomes too high in descending, the whole vibrating frame is raised in contact with projections on the bottom of the car-frame, and the descent stopped. This has been proved effective in handling heavy masses of lead in the establishment of the exhibitors. Several devices for grappling the guides were shown, to take the place of the ordinary racks and pawls.

A number of models of hydraulic elevators were exhibited, most of which provided to operate the car by wire ropes connected to the hydraulic rams by multiplying-pulleys, variously arranged.

Mr. W. H. Harrison, Philadelphia, Pennsylvania, showed a small telescopic elevator, in which one tube is forced out of another, successively, to raise the car. This secures the safety of any form of hydraulic elevator, but permits shorter tubes, and requires less depth of base tube. The large elevators in the pavilions of the New York Court House and Post Office, New York City, which were superintended for the United States Government by the writer, are on this plan, though made by other parties, and are provided with internal dash-pots, to stop the jars when tubes meet. This method is well adapted to secure safety, but involves too much expense to come into general use.

In this connection, it should be mentioned that Messrs. Williamson Bros., Philadelphia, Pennsylvania, exhibited hoisting-engines of superior design and workmanship.

STEAM MACHINERY.

Boiler Proportions.

A report of the trials of the principal steam-boilers exhibited is hereto appended. From the descriptions and sketches embodied in the report it will be seen that most of the boilers were of the so-called "sectional" type, in which the water is contained in small pipes and chambers, to obtain a high factor of safety, though some of the ordinary types were also represented. There were prominent differences in the several boilers in the governing proportions, and in the number, shape, and arrangement of the parts, and it was expected that a comparative trial would show interesting results due to variations, which are desirable in investigating general laws. The experiments do not indicate that mere peculiarities of arrangement or of mechanical details affect, to any material degree, the comparative efficiency of boilers. On the contrary, it appears that, in designing mechanical details to secure the all-

important requisites of safety and durability, the proper governing proportions have been lost sight of, for many of the boilers; and, though the results shown, are, on the average, better than those published for ordinary boilers, none are equal to those obtained with boilers of the marine type, which have been gradually improved by repeated experiment.

It is believed that a boiler with any kind of mechanical details and arrangements, not absolutely faulty, can be proportioned to give the same evaporative efficiency as one of any other form; and in view of the great importance of apparatus for the generation of steam to the industries of all nations, and the special value of improvements tending to the economy and safety of such apparatus, it has been considered proper to collate the results of experiments with other boilers for comparison with those obtained with the boilers on exhibition, and to present therewith general conclusions, which will enable the results to be practically utilized through future improvement.

A large number of experiments with steam-boilers are described in scientific journals and publications, prominent among which are the experiments made at various times for the British Admiralty, those for the United States Navy Department, those made at various national and local exhibitions, those made in 1859, 1862, and 1874 by the *Société Industrielle de Mulhouse*, and elaborate experiments on locomotives made by Mr. D. K. Clark. The most valuable of all for the present purpose appear to be those made during the years 1858 to 1866 for the United States Navy Department, under the direction mainly of Chief Engineer B. F. Isherwood, U.S.N., who was most of that time Chief of the Naval Bureau of Steam Engineering.* Boilers of the water and fire tube types, constructed for naval steamers, were tried with great care under all possible conditions as to rate of combustion, relative size of grate and of area for draft, &c., and all the results were carefully tabulated for reference.

The experiments made previous to the year 1864 left so many questions to be settled as to the proper type and proportions of boilers for the naval service, that a commission of eminent civil engineers was appointed to conduct further investigations, under whose direction two marine boilers were constructed, one with vertical water-tubes arranged above the furnace, the other with horizontal fire-tubes in similar position, with which 177 experiments of 48 and 80 hours' duration were made, during the years 1865 and 1866, reports of which were printed and transmitted to the Navy Department. The experiments were all made by the same force, with similar fuel (anthracite), and great care was taken to secure uniformity in management, so as to determine accurately the true modification in result, due to the particular change of condition or proportion under trial.

The relative quantity of heat transferred through the heating surfaces to the water in a boiler, from incandescent fuel or the heated products of combustion, is a maximum in the furnace, in which the difference in temperature between the heated gases and water is greatest, and rapidly decreases as the difference in temperature is diminished by the exposure of the heated gases to successive areas of water-heating surface. An expression for the rate of conduction has been developed by M. Peclet, and Prof. Rankine shows in his treatise on the Steam Engine that this rate is very nearly proportional to the square of the difference in temperature. The higher values determined in this way, which are due to radiation and conduction from the fuel in the furnace, may be integrated with the successive reduced values, due to the decrease of the difference in temperature, as the gases move toward the chimney,—when, as may be represented graphically, the total areas included between the curve and axes will represent the efficiency for the total heating surface.

The experiments best suited for this purpose were found to be those made with the vertical tubular boiler. This boiler was tested at different rates of combustion with a constant proportion of heating to grate-surface. The low results at the higher rates of combustion obtained in this case are due to the fact that it was necessary to force the draft with either a jet or a blower. Other

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* See Isherwood's *Engineering Precedents*, vol. ii., and *Experimental Researches n Steam Engineering*, vols. i. and ii.

experiments were made, reducing the grate, using the maximum combustion possible with such reduced grate, and experiments were also made with reduced grates, with a rate of combustion less than the maximum. The most valuable series of all were, however, those in which the evaporative efficiencies for different proportions of heating surface were tested, first, by stopping entirely the draft area through tubes, and taking off the products of combustion to the chimney through openings in the back connection; and, second, by successively removing transverse rows of tubes from the vertical tubular boiler, keeping the grate constant.

Professor Rankine (*Steam Engine*, page 281) states that "the free circulation "of the fluids which touch the sides of a solid plate is a necessary condition "of the correctness of the formula for the conduction of heat through that "plate, which has been given in Article 219; and in each of these formulas "it is implied that the circulation of each of the fluids by currents and "eddies is such as to prevent any considerable difference in temperature "between the fluid particles in contact with one side of the solid plate "and those at considerable distances from it." The importance of the free circulation of both fluids to secure maximum efficiency is evident, but the attention of writers and manufacturers has chiefly been directed to the circulation of the water, and the loss of efficiency due to the imperfect circulation of the heated gases along the heating surfaces has not been carefully examined. Imperfect circulation of water may cause overheating and danger, but, if the gases do not circulate thoroughly over heating surfaces, a greater proportion of the heat passes to the chimney, with loss it is true, but without interfering with the regular duty of the boiler. From variations of density, particularly when steam bubbles are formed, a more or less perfect circulation of water will be caused in all locations not exceptionally bad, but as the heated gases are in rapid motion towards the chimney there is little opportunity for the transfer of particles from the interior to the exterior of the various streams, and the heat of the interior portion can be only imperfectly transferred to the heating surfaces by radiation. Moreover, in many boilers there are lines of least resistance, which the heated gases may take on the way to the chimney, that do not lie directly along the heating surfaces, and in other cases there is sufficient area to pass the gases along or between a portion of the heating surfaces in the most direct line to the chimney, so that sluggish currents only are maintained in other portions. The result is that some portions of the heating surfaces have a very low evaporative efficiency, which causes a low average result. The remedy suggests itself of decreasing the area between the heating surfaces so as to force a larger portion of the gases to take a more indirect route, and thereby raise the efficiency of heating surfaces more remote from the direct line to the chimney. Mr. Isherwood has discovered that by reducing the cross-area for draft (or the calorimeter as he terms it) of a tubular boiler the economy is increased; and he accounts for it, partly by the reduced combustion, and partly by the higher temperature in the furnace, due to "the less air dilution attending the less calorimeters."* The latter suggestion does not appear to be supported by later experiments. The general principle appears to be that by judiciously decreasing the area for draft so as to increase the resistance along the most direct lines to the chimney, the products of combustion are better distributed and circulated among and along the heating surfaces, and the average efficiency of the latter increased. It is true that the reduction is unnecessary when there is no well-defined short line to the chimney, as explained hereafter. So, also, some of Mr. Isherwood's experiments appear to contradict the principle. In other experiments made with ferules in the ends of the tubes, reducing the draft area, the results were no higher than before, although the combustion per unit of heating surface was decreased. The explanation is probably as follows: the ferules increased the resistance so that the quantity of gases passing through the several tubes was nearly equalized, but the gases probably flowed along the top of each tube from the contraction at one end to that at the

* Isherwood's *Experimental Researches in Steam Engineering*, vol. ii. page xcv.

other end, and the bottom of the tube was not as effective a heating surface as if the reduced area had been continued the whole length, for which other experiments show economical results.

From the various experiments, the proper area for draft to pass the gases for a given amount of coal may be readily determined, and appears to be about one-eighth of the grate when burning about 12 pounds of anthracite coal per square foot of grate. This corresponds to a combustion of say 100 pounds of coal per hour per square foot of cross-area of tubes for draft. Facts are not available to show definitely whether it is better to use a constant or graduated area of flues or draft-passages from the furnace to the chimney. As the gases move from one to the other they lower in temperature and volume; hence it would seem necessary to have the greater area toward the furnace, and in practice there is generally a combustion-chamber provided. If, upon leaving the combustion-chamber, the gases be passed through a contracted area to secure distribution, a freer draft should be obtained by slightly enlarging the flues in the direction of the chimney, but such enlarged flues might not be fully filled by the heated gases. In a majority of cases the flues are of constant area after the combustion chamber is passed, and the reduction in the volume of the gases by cooling causes such reduction in resistance that a satisfactory draft is obtained; so, on the whole, this practice may be considered the best.

It is recommended that the grate be made of such size that 12 pounds of coal will be burned per square foot per hour under average working conditions, and the rate of combustion should be increased, when the draft will allow, rather than diminished, on account of the carelessness of firemen in attending to large thin fires.

It is believed that the results obtained with the boilers exhibited may be explained in every instance upon the foregoing principles, but it is considered improper to make the application in this place, notwithstanding the fact that nearly every manufacturer may guarantee any performance desired, by ascertaining proper proportions and practically proving their application to his particular details. A few references only will be made, and those of a general character.

First, it will be observed that in a long flue partially obstructed the resistance in different parts of the cross-section is so nearly uniform that the area may be larger than has been previously indicated. The transverse tubes continually break up the current, and the intermediate spaces allow free opportunity for equalization of pressure. The same fact is true to some extent when the water-tubes are staggered so as to require the heated gases to take a tortuous course. So also a flue along the bottom of a boiler may apparently be larger than has been stated, as the heated gases will naturally rise against and roll along the heating surfaces unless the direction of the draft tends to carry them away. For a flue above a boiler the reverse is equally true. In other boilers it will be found that the lines of least resistance do not lead directly through the mass of the heating surfaces, and in others so much area is given that large portions of the surface are ineffective.

It should be mentioned, however, that the boilers at the Exhibition gave, on the average, higher results than those published of many trials abroad,—particularly better than those experimented with by the *Société Industrielle de Mulhouse* previously referred to; but the results with naval boilers previously analyzed are still higher; so there is room for improvement, the direction of which it is hoped will be suggested by the considerations herein expressed.

In proportioning boilers to secure economy the great loss of power necessary should not be overlooked. If insufficient capacity be furnished in any case, dissatisfaction and loss will result, instead of gain. The highest economies cannot be obtained without very high chimneys or the use of mechanical draft. The reduction is less when the passages are broken, as has been explained previously, but so varies with each type of boiler that the law for maximum performance only has been attempted, except in respect to marine boilers with horizontal tubes, represented by curve P, which is of limited application.

The relations between the coal consumed per square foot of heating surface and the evaporation on the standard basis and per square foot of heating surface are shown in the following table, in connection with the corresponding "ultimate efficiencies" previously explained, and the amounts of fuel and quantities of heating surface required per horse-power on the basis stated in the headings. The experiments appear to show that the water-heating surface only should be included in making the comparison. The explanation of this probably is that steam has lower specific heat than water, and that there is generally little provision for rapid circulation in the steam-space of boilers. When the steam-heating surface is specially effective,—for instance, when considerable superheating is obtained or when the boiler lifts water which is evaporated by the steam-heating surfaces,—a portion of the latter should be included in applying the formula or referring to the table.

The table is based upon the highest possible evaporation for the several rates of combustion, so for boilers which have not had their proportions adapted to the peculiarities of their construction a large margin should be allowed to secure certainty in the results, for which the performance of the boilers exhibited will be a safe guide.

1	2	3	4	5	6
c	E	cE	$E \div 15$	$34{\cdot}52 \times 1{\cdot}2 \div E$	$34{\cdot}52 \div cE$
Combustible consumed per Square Foot of Heating Surface.	Water evaporated at Atmospheric Pressure from Temperature of 212°.		Ultimate Efficiency.	Coal (with ⅛ Refuse) per Horse-Power per Hour.	Heating Surface per Horse-Power.
	Per Pound of Combustible.	Per Square Foot of Heating Surface.		On Basis that one Horse-Power requires 30 pounds of Water per Hour evaporated at 70 pounds Pressure from Temperature of 100°, or 34·52 pounds at Atmospheric Pressure from Temperature of 212°.	
Pounds.	Pounds.	Pounds.		Pounds.	Square Feet.
Minimum.	14·20	—	·95	—	—
·1	13·71	1·37	·91	3·02	25·18
·2	13·25	2·65	·88	3·13	13·03
·3	12·82	3·85	·85	3·23	8·98
·4	12·41	4·96	·83	3·34	6·95
·5	12·03	6·02	·80	3·44	5·74
·6	11·68	7·01	·78	3·55	4·92
·7	11·32	7·92	·75	3·66	4·36
·8	11·00	8·80	·73	3·77	3·92
·9	10·69	9·62	·71	3·87	3·59
1·0	10·39	10·39	·69	3·99	3·32
1·5	9·13	13·70	·61	4·54	2·52
2·0	8·11	16·22	·54	5·11	2·13
2·5	7·28	18·20	·49	5·69	1·90
3·0	6·57	19·71	·44	6·30	1·75
3·5	6·00	21·00	·40	6·90	1·64
4·0	5·50	22·00	·37	7·53	1·57
4·5	5·06	22·77	·34	8·19	1·52
5·0	4·68	23·40	·31	8·85	1·48

Calorimetric Tests.

The experiments at the Exhibition suggest some improvements in the apparatus for testing the quality of the steam. As stated in the boiler report, the method of condensing all the steam employed by Professor Thurston is impracticable in most cases. The question is really to select from the various modifications of the original Hirn method of testing a portion of the steam only, and in doing this judgment is required to obtain proper average results. The entrained water may not be equally distributed in all parts of the cross-section of the current, and portions may be carried along the surface of the pipe. It is considered better, therefore, to take steam to the calorimeter from several points in the main pipe at different distances from the centre, or to

withdraw the steam at such velocity that it will take out its proper share of any water present in the form of drops. The pressure in the boiler should, moreover, not be allowed to change during the operation; and to accomplish this supplies to other sources should be properly regulated. It will be remembered that in M. Hirn's first experiments the amount of heat shown by the calorimeter was in excess, and a paper was written by another to account for this by the transmutation of work into heat. M. Hirn afterwards dissented from this view. Means are furnished by the present experiments to explain the phenomenon. It was provided by the Committee at the Exhibition experiments to withdraw the steam through a perforated cross-pipe in the main steam-pipe. To prevent any material difference of pressure in the two, whereby the steam in the former would receive heat from that in the latter, the perforations were made of larger area than the cross-pipe, and the connection from the latter to the calorimeter-pipe was reduced by a nipple to one-fourth the area of the perforated portion. Notwithstanding this precaution, slight superheating was shown by boilers having no superheating surface, which is held to show that some heat was transferred through the perforated pipe. The amount is, however, proportionally so small that it has not been considered. This influence must have been substantially the same for all the boilers, and the results with two of the boilers compare well with those obtained on the trial of similar boilers in New York, in which trials all of the steam was condensed, if the difference in the rate of combustion and allowances then made be considered.

Boiler Furnaces, Fixtures, and Attachments.

An ordinary stationary boiler, used to furnish steam for the engine in the Shoe and Leather Building, was provided with a furnace invented by Mr. J. B. Hoyt, of New York. The furnace proper was an oven lined with fire-brick, and located at one side of the boiler, so that the temperature of the incandescent fuel was not lowered by radiation, and all the heat imparted to the boiler was absorbed from the heated gases. The air introduced to the furnace was heated by passing it through chambers formed in the walls inclosing the boiler. The furnace effectually prevented the formation of black smoke, and experiments made for the inventor by Mr. Theron Skeel showed that there was a perceptible gain from the use of the furnace when burning highly bituminous coal, aad that the results were practically the same as with the ordinary furnace when using anthracite coal. These facts appear to indicate that the apparent greater efficiency of heating surfaces exposed to radiation from the fuel, mentioned by M. Peclet, may be due entirely to the higher temperature, and that equal efficiency should be obtained from surfaces exposed to conduction and radiation from the products of combustion at an equally high temperature. It establishes, moreover, the substantial correctness of integrating the efficiencies of the entire heating surface both in and beyond the furnace, as has been done in the previous examination of the subject of boiler proportions.

The well-known Green Fuel Economizer, manufactured by Messrs. Edward Green and Son, of Manchester, England, was exhibited in connection with the Galloway boiler.

The boiler fixtures and attachments referred to the Group included large numbers of feed-water heaters, low-water detectors, water-gauges, automatic boiler-feeders, whistles, steam-traps, grate-bars, tube-cleaners, damper regulators, as well as scale-preventives, boiler covering compounds, &c., to which it is impossible to refer in detail.

Boiler Inspection.

The Hartford Steam-Boiler Inspection and Insurance Company exhibited specimens of incrustations, scale, and defective iron from steam-boilers, fragments of exploded boilers, &c., illustrating the hidden dangers incident to the use of boilers not properly attended to, or constructed with poor workmanship or of poor material, all showing that the benefits to be derived from a systematic inspection by experts cannot be over-estimated.

The Hartford Steam-Boiler Inspection and Insurance Company was chartered by the Legislature of Connecticut in the spring of 1866, and commenced active operations at once. The statistics of the company since that time show that there have been some 900 boiler-explosions in the country, by which not less than 1,800 persons have been killed and 2,000 wounded. Previous to the organization of this company there was no well-established system of boiler inspection in the country. Several States had enacted laws requiring all steam-users to have their boilers inspected at least once a year, but the execution of these laws was lax. The hydrostatic pump was the principal apparatus used, and very little intelligence was brought to bear upon the subject. The system adopted by this company at the beginning was a thorough internal and external examination, with hammer and chisel, when the boiler was cold, at least once a year, followed by visits. The hydrostatic pump was employed only as an auxiliary,—its use, as generally applied, being considered injurious. The company's business extends over a large portion of the country, being confined mainly to stationary boilers. The company employs twenty-seven trained inspectors, who are constantly occupied in examining boilers under its care, and explosions seldom occur where boilers are placed under this rigid supervision. All the boilers inspected and approved are insured against loss or damage arising from explosion. The company imposes no arbitrary conditions, is interested in no patented appliances, but on receipt of the proposal for insurance, together with the inspector's report, the boilers are classified and accepted at a proper rate per cent., unless they are found to be absolutely unsafe, in which case the applicant is furnished with a written statement of their condition. The policy of insurance covers damage to boilers, building, stock, and machinery, and is a guaranty that the work of inspection has been thoroughly done. The company has some 10,000 boilers under its care. The annual reports of the president of the company contain illustrated descriptions of defects in boilers and of exploded boilers, and will be found both instructive and interesting.

With a view of laying before the group some reliable information of the working of one of the best-known associations for the inspection of boilers abroad, Mr. Charles T. Porter, a member of Group XX., addressed a series of questions to Mr. L. E. Fletcher, chief engineer of the Manchester (England) Steam-Users' Association, which was answered in the following communication, which will be found of great interest.

The Manchester Steam-Users' Association for the Prevention of Steam-Boiler Explosions, and for the Attainment of Economy in the Application of Steam.

Offices, 9 Mount Street, Manchester,
July 4, 1876.

To the Judges of Group XX., Centennial Commission, Philadelphia.

GENTLEMEN,—In reply to a letter received from Mr. Chas. T. Porter, requesting information as to the working of the Manchester Steam-Users' Association, for the use of the Judges of the International Exhibition, Philadelphia, I beg to forward the following particulars, and in doing so will take up the points seriatim in the order in which they occur in Mr. Porter's letter:—

No. 1. "*Term of Existence.*"—The Association was established in the year 1854, and has been in active work ever since, increasing in the number of boilers and the area of its operations.

No. 2. "*Average and Present Number of Boilers in Charge.*"—The number of boilers now under inspection is, as nearly as may be, 3,000. The average for the last five years has been 2,500.

No. 3. "*Character of the Boilers, and if of Different Types, the Number of Each.*"—By far the greater number of boilers enrolled with the Association are horizontal and internally fired. Speaking approximately, the relative number of the various types is as follows:

50 per cent. are what are termed "Lancashire" boilers,—that is to say, having two internal tubes running through them from end to end in which the fires are placed.

15 per cent. are of the "Cornish" type,—that is to say, having one furnace tube running through it from end to end, in which the fire is placed.

15 per cent. are externally fired, such as plain, cylindrical, egg-ended, colliery boilers; French or "Elephant" and "Butterly" boilers.

8 per cent. are variations of the "Lancashire" and Cornish boiler, with a number of small flue tubes, some termed "Multiflued" and others "Multitubular," &c.

6 per cent. are of the "Galloway" type.

6 per cent. are of the miscellaneous types, such as boilers at iron-works, heated by flames passing off from puddling and iron furnaces, water-pipe boilers, locomotive and marine boilers, and vertically internally hand-fired boilers, &c.

These proportions vary somewhat year by year as boilers are changed.

No. 4. "*Pressure carried between what Limits.*"—All the "Lancashire" boilers made for the members under the inspection of the Association, the ruling diameter of which is 7 feet in the shell, and 2 feet 9 inches in the furnace tubes, are fit for a working pressure, as a minimum, of 75 pounds on the square inch. Many are fit for a working pressure of 85 pounds, others 90 pounds and 100 pounds. No new boilers are made to the Association's standard for a lower pressure than 75 pounds on the square inch. Many smaller boilers are carrying 120 pounds.

No. 5. "*Character of the Examinations made and their Frequency.*"—A complete examination of each boiler is made both inside and outside, when at rest and properly prepared, at least once a year, and more often if necessary,—that is to say, if the boiler does not appear thoroughly sound or repairs have to be examined. Hydraulic tests are also had recourse to when necessary. In addition to the annual thorough examination, two external examinations of each boiler are made per annum with the boilers at work and steam up. This number is a minimum.

No. 6. "*Nature of the Defects discovered and the Number of each per Annum.*"—The following is a list of the defects discovered, with the number of each, for the year 1875:—

Furnaces out of shape	22	defects.	3	dangerous.
Fractures	87	„	10	„
Blistered plates	79	„	6	„
Internal corrosion	163	„	5	„
External corrosion	104	„	21	„
Internal grooving	117	„	1	„
External grooving	9	„	2	„
Feed-apparatus out of order	1	„	—	„
Water-gauges „	7	„	—	„
Blow-out apparatus „	14	„	3	„
Fusible plugs „	6	„	—	„
Safety-valves „	30	„	18	„
Pressure-gauges „	110	„	7	„
Boilers without glass water-gauges	2	„	—	„
„ safety-valves	8	„	1	„
„ pressure-gauge	6	„	4	„
„ blow-out apparatus	6	„	—	„
„ feed-back pressure-valves	51	„	—	„
Cases of over-pressure	9	„	5	„
Cases of deficiency of water	2	„	1	„
Total	833	defects.	87	dangerous.

No. 7. "*Instructions given to Owners and Firemen.*"—We have no written code, but are thinking of preparing a list of instructions to firemen. All we ask from the owners is to get a good boiler and a careful man. We impose no arbitrary conditions. Information to the owners is always accessible at these offices.

No. 8. "*The Guarantee afforded to Members.*"—The Association guarantees the members freedom from explosion from year after year. As a pledge of good faith, the reports are indorsed with a pecuniary guarantee of 300*l.*; but the Association has no explosions. The only exception to this was the rending

of a furnace through over-heating, in consequence of misuse by the owner, who charged the boiler heavily with caustic soda and arsenic,—bringing down the incrustation, but yet neglecting to blow out. No one was hurt, and the boiler was soon repaired and set to work again. We warn our members against using compositions and neglecting to blow out. We guarantee perfect immunity from explosion provided only they meet us with ordinary fairness. Year after year we are able to report, "*No explosion from any boiler guaranteed by the Association.*"

No. 9. "*The Cost to Members of the Inspection and Guarantee.*"—The charge for inspection is one guinea and a half per annum each boiler, within a radius of 40 miles of Manchester; beyond that distance, according to arrangement. There is no charge for guarantee. The Association's guarantee is neither to be bought nor sold. If the Association considers a boiler unsafe, nothing will induce it to say it is safe. If the boiler is safe, there is no need to charge for saying so. The expense is incurred in inspection, and the Association has no explosions to make compensation for.

No. 10. "*The Result of the Work of the Association in Immunity from Accidents.*"—It is presumed that by the word "*accidents*" is meant "*explosions.*" We do not approve of the word "*accidents*" as applied to explosions. Explosions in the great majority of cases are not accidental: they arise from known causes. Inspection is able to prevent their occurrence, and is found in the experience of the Association to be quite adequate. *See here reply to question No.* 8.

No. 11. "*Upon what do you rely for Safety?*"—Upon competent periodical inspection. *See reply to questions* 8 *and* 10.

No. 12. "*Low-water Detectors.*"—We recommend that each boiler should have two good glass water-gauges, fixed directly to the front end plate of the boiler, immediately under the eye of the attendant. We approve of a low-water safety-valve, which relieves the pressure of the steam as soon as the water falls below the desired level. Alarm-whistles may be easily silenced, and, as a rule, have been discarded. A low-water safety-valve is more reliable, as it blows off either for high steam or low water, and thus is kept in constant play.

No. 13. "*Automatic Feed-Regulators.*"—We do not approve of these, thinking them apt to mislead, and to engender a false confidence; we prefer feeding by hand as more trustworthy.

No. 14. "*Testing Boilers in use by Hydrostatic Pressure.*"—We do not adopt this course as a rule, and only adopt it when there is some peculiarity in form, say to ascertain the strength of a flat surface, or when any question arises as to the power of a furnace tube to resist collapse. In the case of the cylindrical shells of boilers we rely on careful inspection. If the plates appear to be washed we drill them to ascertain the precise thickness, and sound the rivet-heads to see if corrosion is interfering with the consistency of the metal. We have the boiler so set that all parts may be accessible to examination. If the brick-work interferes we have it removed. When hydraulic tests are applied, the boilers are gauged at the flat ends, and also in the furnace tubes, to see if any movement occurs. We have no faith in blind hydraulic tests for getting at the strength of parts out of sight. Our rule is to see everything.

No. 15. "*The Experience and Approved Usages of other Similar Associations in England.*"—The object of the Manchester Steam Users' Association is the saving of human life and the prevention of explosions. It has no shareholders, and pays no dividends. The President and members of the Executive Committee give their time gratuitously year after year in the interest of the members and the public generally, with the object, as already stated, of saving life. There is no other similar association in the country, but there are joint stock boiler insurance companies founded for the purpose of dividend.

No. 16. "*The Degree in which the System of compounding has taken the Place of Expansion in the Single Cylinder in the Manufacturing Districts of England, and what are the Views of leading Steam-Engine Builders as to the Relative Advantages of the Two Systems, so far as known to you?*"—Practically speaking, of the "compound" system is more generally adopted than the "simple," or single cylinder system; still, the simple system has its advocates, and the question is still a vexed one as to which of these two systems is the better, but for high pressure there is no doubt that the "compound" system is in more general favour.

No. 17. "*In what Degree Direct-Acting Engines are coming to supersede the beam-Engine?*"—Direct-acting engines are almost entirely superseding beam-engines, more especially for high pressures. It is a very general system to lay two horizontal systems side by side and place the cranks at right angles, arranging one cylinder to be the high pressure one, and exhausting into the other, which is the condensing one. With this arrangement but one condensor and one air-pump are required. A steam reservoir is sometimes placed between the two cylinders, but not always. The plan of regulating the cut-off in high-pressure cylinders by the governer is coming increasingly into favour. Sometimes new high-pressure beam-engines are laid down on the McNaught principle. This, however, is rarely done. Many beam-engines are compounded with a horizontal high-pressure cylinder.

I think I have now replied to all the questions contained in Mr. Porter's letter, but may add that our Association goes to the expense of sending a qualified officer to investigate every explosion that occurs in any part of the country, and draw up a full report with illustrative drawings of the same. These are carefully preserved at these offices, and form most instructive and valuable documents. A very abridged statement of the description of boiler, course of the rents, effects of the explosion, and the cause is given in a tabular synopsis published in the Association's printed monthly reports, circulated among the members and sent to the press gratuitously, so as to disseminate the information as widely as possible. See report for December 1875, inclosed herewith. Sometimes these monthly reports are made the vehicle for conveying suggestions on compoundings, &c. See report for December 1874, inclosed herewith. I also enclose a synopsis, which gives the rules of the Association, with further information as to rates, membership, visits of inspectors, &c.

The Association has boilers enrolled under its inspection situated in all parts of the United Kingdom; also it has several corresponding members abroad, and is affiliated with another institution for the periodical inspection of boilers at Calcutta. Its monthly reports will be found in the Library of the Franklin Institute at Philadelphia.

Trusting that this information will be of service to you, and wishing you every success in your labours,

I remain, gentlemen,

Yours faithfully,

L. E. Fletcher,

Chief Engineer.

Injectors.

About the year 1858–59 Mr. Giffard, of France, produced his now well-known injector, or continuous boiler-feeder. In this instrument a jet of steam from the boiler is made to draw in a quantity of water, and force that water into the same boiler against its own pressure, or even to force it into another boiler carrying steam at a higher pressure. This striking invention was for a time classed among mechanical paradoxes, but familiarity with it, as with other notable inventions, which seemed very astonishing at first, has dissipated the charm that hung about its novelty. Some look upon it as a beautiful illustration of the correctness of the laws of physics which govern it, while others care little how it does work,—accepting its operation as a fact. To our Centennial Exhibition we naturally look for information as to what improvements, if any, have been made in inventions of this character when transplanted into a new soil. Few inventions from abroad retain long, in a new land, all the characteristics of the original; the modes and methods of the country must modify all engineering structures, no matter how small or how simple in detail. This particular invention was one that attracted attention from its beginning. It was almost immediately taken up in England, and soon after in the United States.

The introduction of the Giffard injector in this country was made by William Sellers & Co., of Philadelphia, in 1860, and they were, during the continuance of the original patent, the sole licensees and manufacturers under that patent in the United States, and have made, from time to time, improvements in the instrument. In 1865 they introduced the novel and important principle of self-adjustment. Previous to this injectors had either fixed nozzles or were

arranged with independently adjustable nozzles, separately operated to adapt the steam and water supply to each other, and to the changes in the boiler pressure, &c. In these injectors any want of proper adjustment was indicated either by a waste of water or in-draft of air at the overflow, and if, after a most careful adjustment of the parts to produce the best results, the steam pressure in the boiler changed, the instrument would work badly until re-adjusted for the new conditions. The self-adjusting instruments have no waste at the overflow. After starting, the steam-supply alone is adjusted by hand, and the water-supply is automatically regulated, so that the steam is always combined with the exact quantity of water necessary to produce the best results, no matter how much the steam pressure in the boiler may vary. This instrument in its improved form went through various changes for the better up to the year 1876, when a new style, the "Injector of 1876," was exhibited at the Centennial, after careful tests on leading railroads.

The advantages of using an injector to feed the boiler of a locomotive are that it may be operated to deliver the water in a continuous stream, either when the engine is at rest or in motion, and it furnishes heated water at all times, even when the tank has been freshly filled. To obtain the full advantage of the injector when the locomotive is running regularly, the manipulations of the instrument required to start and regulate the feed should be simpler than those necessary in the use of the pump. The "Injector of 1876" was designed to accomplish this object, and is put in operation and regulated entirely by moving a single handle. Through a fixed receiving tube the principal jet of steam passes, being regulated by the position of the interior conical spindle. The annular jet of steam combines with water in the combining-tube, and the concentrated jet is forced through a delivery-tube and the check-valve to the boiler. The combining-tube forms part of the piston, which fits freely into the case, and the smaller end of the combining-tube slides freely also in the end of the delivery-tube. The pressure of the water is on one side of the piston, and the other side is in communication with the jet issuing from the combining-tube through an opening inside of the delivery-tube. If the water-supply be too great, a portion escapes through the opening, and accumulating in the surrounding chamber forces the piston and combining-tube toward the receiving-tube, and contracts the annular space between the two latter, so that the water-supply is reduced. If the water-supply be insufficient, a partial vacuum will be produced in the chamber, and the piston moved to admit more water. In this manner the supply of water is automatically adjusted to suit all requirements.

The description thus far is common to all the Sellers' self-regulating injectors. In the "Injector of 1876" the central spindle in the receiving and combining tubes is secured to an operating-spindle, and has a small bore throughout its length, which receives steam through small openings, when the valve on the operating-spindle is raised from its seat in the top of the larger valve, which admits steam to the receiving-tube around the central conical spindle. The operating-spindle is moved through the arm and slide by the operating-lever, and the latter by means of the rod with stops upon it operates the screw overflow-valve on the stem. In the position shown steam is shut off, and the overflow-valve is open. Upon moving the lever the valve is first opened, and steam is admitted to the small bore of the central spindle, and issues in a jet, which induces a current in the water-supply pipe, whereby the air is withdrawn, water lifted and expelled at the overflow. (The lifting effect desired is quite dissimilar from the action of the annular jet in operation as a boiler-feeder, being more nearly allied to the action of the exhaust in producing a draft in the smoke-pipe of a locomotive, and requires a high velocity and free expansion at the moment of escape.) When the water is lifted, by moving the handle still more, a collar on the central spindle comes in contact with and opens the large valve, thereby admitting steam to the annular jet to produce regular operation, as previously described, and the handle, upon being moved back to its extreme position, strikes the stop on the rod, and thereby shuts the overflow. At the same time a pawl drops into a rack on the arm, and holds the lever in position when the latter is pushed in to regulate the flow. This pawl is lifted and caught fast, when the lever is pushed entirely in to stop the injector, and not relieved again till the lever is at the other extreme, as above explained. The instrument can be located in any convenient position on a locomotive above the

water-level in the tank, as it is considered advantageous to have the injector lift its supply of water.

In addition to the feature of improvement to secure convenience of manipulation, the efficiency of the instruments has been materially increased in several important particulars. The members of the group who specially reported on injectors did not find it possible, as requested by Messrs. William Sellers & Co., to undertake elaborate tests with injectors, but from the results of numerous experiments made by that firm as a basis for initiating improvements and making guarantees of performance, the writer has made several selections, which are hereafter presented.

On a locomotive economy is secured by utilizing surplus steam to heat the water in the tender, and the hotter the water the injector will feed the greater is its practical utility as a boiler-feeder. In using the "Injector of 1876" no difficulty can be observed in starting after steam has been blown back through it to heat the water in the tank. The quantity of water that can be made to pass through any given-sized opening, arranged on the conditions which obtain in all injectors, depends upon two conditions, viz., the pressure of the steam and the temperature of the feed or supply water. The colder the latter the hotter may be the steam used to inject it, and *vice versâ;* so that any improvement in an instrument that will enable it to approximate the theoretically possible combination of temperatures of steam and water is of great importance. The improvements made in this respect are shown by the following table:—

Steam Pressure.	Admissible Temperature of Feed.	
	Old-style Injector.	Injector of 1876.
Pounds.	Degrees Fahrenheit.	Degrees Fahrenheit.
10	148	—
20	138	138
30	130	—
40	124	135
50	120	—
60	—	130
80	—	130
100	110	132
120	90	133
150	—	128

If this result were obtained by any sacrifice of range of the instrument, it is doubtful whether it would be advantageous to employ it. The limit of range of any injector is in a degree dependent upon the temperature of the feed-water; but it is claimed for the new instrument that it works through a greater range with varying conditions of temperature of feed than any instrument yet made. The relative ranges for several injectors, found by experiment, are shown in the following table, the maximum delivery in cubic feet or other unit of measure being called 100 units:—

	Maximum Delivery.	Minimum Delivery.	Range.
	Units.	Units.	Per Cent.
Giffard adjustable - -	100	60	40
Sellers self-adjusting -	100	50	50
„ Injector of 1876 -	100	40	60

Experiments further show, in addition to the increased original temperature of water which the injector will receive, and the increased range between maximum and minimum deliveries, that the new instrument, in common with the other self-adjusting instruments, has a higher maximum than the original Giffard adjustable injector. For the purpose of comparison, the writer has selected the following from the tables of capacity furnished to enable purchasers to select instruments of proper size. The term No. 6 signifies that the minimum diameter of the delivery-tube is 6 millimetres.

Steam Pressure.	Cubic Feet of Water discharged per Hour.		Steam Pressure.	Cubic Feet of Water discharged per Hour.	
Pounds.	No. 6. Giffard.	No. 6. Self-adjusting.	Pounds.	No. 6. Giffard.	No. 6. Self-adusting.
10	46·5	83·5	90	103·5	140·4
20	58·0	90·6	100	113·9	147·6
30	67·5	97·7	110	119·1	154·7
40	76	104·8	120	124·0	161·8
50	83·5	112·0	130	128·7	169·0
60	90·3	119·1	140	133·3	176·1
70	96·7	126·2	150	137·5	183·2
80	102·8	133·3			

The No. 7 Giffard injector, one size larger than the example above, discharges at 120 pounds a pressure of 169·3 cubic feet. The No. 6, self-adjusting, as above, discharges 161·8 cubic feet, so, at the maximum, the capacities of the new instruments are practically the same as those of the original Giffard instruments respectively one size or number larger.

Messrs. Nathan and Dreyfus, of New York, exhibited the Friedman injector in various forms. This instrument is the invention of Mr. Alexander Friedman, of Austria, and was introduced in the United States by the exhibitors, who have added some improvements. The steam enters at the upper end, passes in a jet through the receiving-tube, and combining with a first supply of water in the conical intermediate combining-tube, the jet issues from the latter with sufficient velocity to induce and combine with a second current of water from the annular space below, when the concentrated jet is forced across the overflow-chamber to the boiler in the usual way. For lifting the water, an independent small jet is provided in a tube at the side. This tube and jet are omitted in "non-lifting" injectors.

This instrument is remarkably simple, and it is to be regretted that its efficiency in comparison with other forms of injectors has not been authoritatively established. The capacity of a No. 6 injector in gallons per hour is given in the exhibitors' circular as follows: steam pressure 120 pounds, capacity per hour 870 gallons; steam pressure 80 pounds—720 gallons; steam pressure 63 pounds—570 gallons; steam pressure 20 pounds—360 gallons. The circular states also that the maximum temperature at which the injector will operate is 140°.

The same firm also exhibited ejectors for raising water and conveying liquids. In this case the high velocity of the original small jet is reduced and utilized by combination with volumes of water successively drawn in by the induced currents at the several openings.

Air and gas exhausters, resembling in construction the ejector last described, were exhibited by Messrs. Shutte and Goehring, of Philadelphia. The advantages of such a system for use when the steam pressure is in excess of that to be overcome are evident, as the original high velocities are utilized in putting successively in motion increased volumes. It is desirable, however, to know whether there is such a surplus of velocity with ejectors acting under pressure as to make it comparatively economical to employ the system, even to the extent of a duplicate water-supply. In this connection it may be stated that there have appeared, simultaneously apparently, both in Europe and the United States, but by different inventors, injectors in which the steam-jet instead of the water-supply is duplicated; one jet forcing water to the second, which delivers it at the higher final pressure and velocity. Experiments would be of great interest, showing the advantages, if any, to be derived from either of these two contrary methods of operation as compared with the single steam and water jet of the original Giffard injector with modern improvements.

The duty of an injector when used simply for lifting water is very low. From some experiments made by the writer in 1865* with a small Giffard injector delivering 20 cubic feet per hour, using steam varying for the several experiments from 61 to 70 pounds, and water pressure varying from 40 to 76 pounds, it was found that the injector delivered under different relations of pressure and

* See *Journal Franklin Institute*, January 1866.

adjustment from 13 to 17 times the weight of steam required to operate it. In 1869, Mr. John Bourne published some similar experiments* with an injector of three times the capacity of that mentioned above, using a steam pressure of from 30 to 40 pounds, and water pressure as high occasionally as 90 pounds, from which it appears that several of the experiments showed a delivery of from 16 to 20 times the weight of steam used. The best result was a delivery against a pressure of 90 pounds of 16 times the weight of steam used, which is equivalent to lifting 16 pounds of water about 207 feet high for each pound of steam used, or to 3,312 foot-pounds. On the basis that a moderate-sized steam-pump may require 60 pounds weight of steam per horse-power per hour, or one pound for each 33,000 foot-pounds of work, the duty of the injector for simply lifting water appears to be about $\frac{1}{10}$ of that of a steam-pump.† This simply shows that it is doubtful whether any injector can be economically used for lifting fluids in competition with pumps, except in cases where it is desirable to raise the temperature of the fluid at the same time. In an injector little of the heat of the steam is expended in work, but the remainder goes to raise the temperature of the fluid operated upon, and in feeding the boiler is entirely utilized. For boiler-feeding, then, the injector is more economical than the pump, except in cases where the feed-water can be heated by waste steam to a considerably higher temperature than the injector will receive it.

STEAM-ENGINES.

The Corliss Engines.

The main lines of shafting in Machinery Hall, referred to under the head of "Transmission of Power," were all operated by a pair of beam-engines, located at the junction of the transept with the south nave. These engines, from their great size and original design, formed by far the most prominent exhibit in the building, and received much attention from engineers, the public, and the press. Mr. George H. Corliss, of Providence, Rhode Island, the inventor and manufacturer, provided the engines and boilers, and also furnished and put in all the foundations for the machinery and supplied all the connecting-pipes, with the shafts and all the appurtenances connected with the transmission of power from the engine to the nine main belts.

Mr. Corliss, being a member of the Centennial Commission and of the Executive Committee, would not allow his exhibits to be entered for competition, and, consequently, under the rules adopted by the Commission, they did not come before the Judges for examination and report.

There were two condensing beam-engines, which were proportioned to work expansively, with a steam-pressure of 80 pounds. The valves and valve-gear were of the style peculiar to Mr. Corliss, with several improvements specially designed for, and first applied to, these engines. The cylinders were each 40 inches in diameter, with 10-feet stroke of piston. The beams were 27 feet long by 9 feet deep, and weighed 11 tons each. The engines were connected at right angles to a main shaft carrying the fly-wheel, which was a cut gear-wheel, 30 feet in diameter, with a face width of 2 feet, and a weight of 56 tons, and is believed to be the heaviest cut-wheel ever made. It geared with a pinion 10 feet in diameter, on a main line of under-ground-shafting 256 feet long, running across the building. This line of shafting was connected by bevel-gears, 6 feet in diameter, at each end, and at two intermediate points with shafts running longitudinally of the building, from which belts were run up through the floor to eight lines of over-head shafting, each having a length of 658 feet. The main shaft was also continued southerly 100 feet under the floor of the transept to operate a line of shafting in the Pump Annex.

The fly-wheel made 36 revolutions per minute, giving a piston speed of 720 feet per minute. The gears were cut by machinery devised and constructed for the purpose by Mr. Corliss, and ran with remarkable smoothness of motion and freedom from noise, notwithstanding the fact that the peripheral velocity of the spur-gears was 3,384 feet per minute, or about 38 miles per hour. Some of the most delicate machinery operated by exhibitors, such

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* Appendix, *Steam, Air, and Gas Engines*, by John Bourne.

† For small steam-pumps the ratio would be $\frac{1}{4}$. (See close of article on *Steam Pumps*.)

as that of the Waltham Watch Manufacturing Company, was conducted on the floor over the bevel-gearing.

The engines were rated at 1,400 horse-power, which could be increased to 2,000 horse-power when required. They operated without appreciable vibration, and no stoppage was made on account of hot bearings or any derangement of any part of the machinery. The cylinders were jacketed with live steam, and were kept hot continuously from the hour of opening, May 10, till the formal closing on November 10.

There were twenty vertical boilers furnished by Mr. Corliss, which were erected in a separate building. A portion of them supplied steam to the main engines above described, the others were sometimes used to supplement the steam-supply to the Pump Annex. Each boiler contained 48 tubes, 3 inches in diameter, in a shell 4 feet in diameter and 14 feet high. The aggregate heating surface in the 20 boilers was reported to be 13,000 square feet.

The material of the above exhibit, on its re-transportation from the Exhibition to Providence, loaded 71 cars, the aggregate weight being upward of 776 tons.

STATIONARY AND PORTABLE ENGINES.

For reasons previously mentioned no attempt will be made to describe the distinguishing features of the large number of stationary and portable engines exhibited. A few have, however, been selected to illustrate the application of different types of valve-gear.

Engines regulated by the action of the governor on a throttle-valve operate under two important disadvantages: first, the regulation is not perfect, no matter how good the governor, for the reason that they must necessarily be considerable space between the throttle and main valves, which tends to retard the regulation by furnishing an additional supply of steam when the throttle is closing and absorbing a portion of the steam supplied as the throttle is opening; second, the initial pressure in the cylinder is diminished, which reduces the economy, as is well understood and shown by experiments referred to hereafter; the system, moreover, does not enable the benefits due to free expansion to be utilized.

The principal improvements which caused the high degree of efficiency of modern steam-engines for manufacturing purposes were initiated in the year 1849 by Mr. George H. Corliss, of Providence, Rhode Island, by the invention of his well-known cut-off, tripped automatically by the action of the governor, so as to proportion accurately the supply of steam to the load to be overcome, and at the same time utilize, in the cylinder substantially the full boiler pressure and expansive effect of the steam, and thereby secure economy in the use of steam and fuel.

The segmental valves, adopted by Mr. Corliss and known by his name, secured also the further economy due to the reduction of the area in cylinder passages to a minimum. The arrangement of the exhaust valves in the bottom of the cylinder secured still another advantage, which, etrange to say, is not appreciated by all manufacturers—that the cylinder is not only cleared of water in starting, but, in regular working, a free exhaust in such position carries out most of the moisture in the steam due to the performance of work in the cylinder, and there is less to be re-evaporated by radiation from the walls of the cylinder which must be re-supplied during the next stroke, at the expense of the fuel. The success attending the improved mechanism of Mr. Corliss, and the business manner in which it was introduced, naturally gave an impetus to invention on the subject, and many engines with governor cut-offs were developed, though but few obtained a standing in the market. The main valves or independent cut-off valves were operated by cams, revolving eccentrics, and secondary steam-cylinders, and many modifications of the trip cut-off were designed, but the latter did not go into general use while the original Corliss patent was in force.

Mr. P. Van den Kerchove, of Ghent, Belgium, exhibited Corliss and Rider engines of excellent design and finish. The former was of 160 horse-power, and was made for the Belgian mint.

The Rider engine is so named from the cut-off, which is an American invention, represented by Messrs. C. H. Delamater & Co., of New York. In

these engines a double main slide-valve is used with a concave semi-cylindrical cut-off valve-seat on the top. The main valve has steam-ports through the ends, which, being twisted as they rise, issue through the cut-off valve-seat on spiral lines, of reverse pitch, at the two ends of the valve. The cut-off valve is a cylinder with corresponding spiral ends, and receives a positive longitudinal motion from an eccentric. The cut-off is adjusted by simply revolving the valve partially, thus causing different portions of the spiral-ended cylinder to close the cut-off ports and thereby suppress the steam at different parts of the stroke. No balancing arrangement is used, and none is needed, as the longitudinal motion is comparatively large, and is resolved with the lateral force applied through an arm from the governor, so that the motion of the valve over its seat is diverted from a right line to a long spiral. When the engine is in motion the cut-off valve can be turned by applying the hand to the valve-stem, and, as might be expected, the engine is under full control of the governor.

The engine which operated most of the machines in Agricultural Hall was furnished by Mr. Jerome Wheelock, of Worcester, Massachusetts. There is one main and one cut-off valve of the segmental type provided for each end of the cylinder. Each main valve has an exhaust-cavity, and operate in the same manner as an ordinary slide-valve. The cut-off valve regulates the supply to the small steam-chest containing the main valve, and as the latter never communicates with the exhaust, slight leaks of the cut-off valve do not appreciably affect the economy. The valves are made a little conical, and are each provided with a steel bush to run on a stationary pin secured to one of the bonnets. To the smaller end of the valve is secured a hardened steel stem, which runs through a steel bushing in the other bonnet and the shoulder on the stem bears against the steel bushing making a steam-tight joint, and no packing is required for the valve-stem. The steel bush is so adjusted that the valves are pushed back from their seats sufficiently to transfer the wear to the steel bearings, and yet maintain steamtight joints between the valves and seats. Valves were shown which had been in use for a long period, on which the surfaces were highly polished, indicating that they had been steam-tight, and there was no perceptible wear on the bearings. Motion is originally applied to the main valves, and pawls from their operating arms drive the cut-off valves, the pawls being released by cams carried on the cut-off valve-stems, which are adjusted by the governor through the gears, arms, and links shown. The valves are closed by weights checked by dash-pots.

The Wheelock steam packing is made in segments with a finger formed on one end of each to enter a corresponding cavity in the adjoining end of the next. Two such rings are provided and placed in grooves in a skeleton piston. These pistons are simple and light, and operate very satisfactorily.

An engine exhibited by the Buckeye Engine Company, of Salem, Ohio, contained a number of remarkable and ingenious features.

The main valve is box-shaped, and slides between the valve-seat on one side and balancing pistons communicating with a chamber in the steam-chest cover on the other. Steam is admitted through this chamber and the balancing pistons to the inside of the valve, and the exhaust escapes at the ends of the valves to the space surrounding it. The cut-off valves are simple connected plates arranged to slide upon a valve-seat inside the main valve, and are operated by a stem running through the main valve-stem. The cut-off valve-stem is operated by an eccentric on the main shaft, which is advanced or retracted angularly to vary the cut-off, by a governor arranged within a pulley on the main shaft and revolving therewith. Two levers, pivoted, carry weights, which, by centrifugal force, when the engine is in motion, tend to move outward and overcome the resistance of springs. The ends of the levers are attached to lugs on the eccentric. The fact that the cut-off valves are unbalanced should apparently render the governor unsteady in its action; but the friction of the valve is part of the resistance to be overcome by the centrifugal force, and acts in the same direction as the springs; and sufficient mass being provided to prevent extreme movements, from the regular variations of resistance due to the closing of the valve at each end of the stroke, and the average resistance being practically uniform, it appears as a fact that the engine is under the full control of the governor, and the indicator diagrams are remarkably perfect in appearance.

A governor similarly arranged on the main shaft was applied to adjust the main valve of the Hoadley portable engine, and is described in the report of the trial of that engine hereto appended.

Mr. Wm. Wright, now of Newburg, New York, at an early date designed a number of cut-offs, varied by the governor, in which, generally, horizontal poppet-valves were used, operated by a cam on a shaft geared to the main shaft; the adjustment of the cut-off being made by shifting position of the rear of the cam in various ways. In several modifications by Mr. Wright and others, the poppet-valves were arranged vertically, and in certain cases slide-valves in similar position were substituted, the valves of either kind being tripped to drop freely or lowered by an adjustable cam. Engines showing different applications of these features were exhibited by the Hartford Foundry & Machine Company, and by Messrs. C. W. Browne & Co., of Fitchburg, Massachusetts. The engine last-named operated most of the achinery in the Saw-Mill.

A pair of horizontal stationary engines of the compound intermediate receiver type were exhibited, also an engine in which the cut-off was regulated by an ingenious modification of link-motion, the details of which are not at hand. A large number of stationary engines of various sizes were shown with valve-gear of the ordinary types.

The Wells Balance Engine Company, of New York, exhibited an engine with two pistons in the same cylinder. There were triple cranks, of which the centre one was opposite the other two. The nearest piston connected in the usual way to the central crank, the farther piston connected by two rods running through the other piston and front cylinder-cover, with a pair of connecting-rods running to the outer cranks. A single slide-valve distributed steam alternately between the two pistons and by a forked port to both ends of the cylinder. This engine being almost perfectly balanced was run at a high rate of speed, and developed very great power in proportion to its size and the space occupied.

No high-speed engine of large size with details especially designed to secure economy of fuel, as in the Porter engine, at the Paris Exhibition, was exhibited, though the speed of some of the engines shown was higher than the usual practice, and the indications were that higher speeds were considered desirable. All new trains in rolling-mills are now operated by engines directly connected with the rolls, and marine engines of the largest size have for a considerable time been run at the full speed of the propeller shafts. The advantages of high speed are that the inequalities of pressure in the cylinder due to the expansion of steam are distributed throughout the stroke, great smoothness of working is obtained, and engines of less size are required for a given power.* To secure these advantages, however, with large engines requires the use of proper details of construction.

The New York Safety Steam-Power Company, of New York City, exhibited a number of vertical engines of different sizes, designed to run at a high speed, for use in small steamers or manufactories. These engines are constructed on the modern system of interchangeable parts, made accurately to gauge, as developed in gun and sewing-machine manufacture. The design is pleasing, and has been closely imitated by other builders.

The portable engines exhibited by the Baxter Steam-Engine Company, of New York, were also built with interchangeable parts by the Colt's Arms Company, of Hartford, Connecticut. These engines were used to operate the machinery in the Glass-house, the Nevada State Building, and in other locations. Portable engines of excellent design were also exhibited by Messrs. Shapley & Wells, Binghampton, New York, and other exhibitors. A report of the trial of the Hoadley portable engine by a committee of the Group is hereto appended.

Rotary Engines.

It may be safely stated that experienced engineers have little faith in rotary engines of the well-known type for the economical development of power. Much ingenuity has been expended upon the subject, but the difficulties of obtaining tight wearing surfaces are apparently insuperable. Such engines,

* See *a Treatise on the Richards Steam-Engine Indicator*, by Mr. Charles T. Porter.

however, offer advantages on account of their compactness and simplicity when economy of steam is of secondary importance. For instance, a small hoisting-engine used but little may as well be of this character, since, considering first cost and reliability under conditions of neglect, in connexion with the quantities of steam used, it may prove more economical in the end than other forms. The rotary fire-engines illustrated in the fire-engine report, presented herewith, are also well adapted to their work, and have advantages peculiarly their own. A number of rotary engines of different forms were exhibited, but the only one believed to possess novel as well as exceptional features was that invented and exhibited by Richard Dudgeon, New York. As in other forms of rotary engines, there are two spur-gears with long engaging teeth, but the steam is admitted at the side *between* the teeth, near the line joining the centres of wheels, and acts to separate the wheels on a line above or below their centres, thereby producing rotary motion. The case is not necessary to secure operation, as it contains only exhaust steam. Two plates on the side of the wheel where the teeth engage are all that are essential, steam being admitted through an opening in one of them. By shifting the plate containing the opening up and down by hand or with a governor, the expansion may be varied to regulate speed, and by moving this opening the other side of the line joining the centres of the wheels the engine will be reversed. An engine of this kind has been running for six years in New York with superior economy to the ordinary engine formerly employed, and is in as good condition as when first started. Steam does not blow through, and there is a definite exhaust as each tooth is released.

MARINE ENGINES.

The largest marine engines shown were those exhibited in the Government Building by the United States Navy Department, and consisted of a pair of horizontal engines for the United States steamer *Nipsic*, with cylinders 36 inches in diameter and 36 inches stroke of pistons, and a pair of horizontal compound engines, of the intermediate receiver type, for the United States steamer *Epervier*, with cylinders 34 and 51 inches in diameter and 42 inches stroke of pistons. Boilers for use with the latter were also exhibited. The engines were quite compact, and very well designed and finished.

A small compound marine engine with vertical cylinders was exhibited by the Motala Iron & Steel Company, Motala, Sweden. The Kristenehamn Machine Manufacturing Company, of Kristenehamn, Sweden, also exhibited a small marine engine, and the Köping Mechanical Works, Limited, Köping, Sweden, the cylinders for a 60 horse-power propeller engine. The Swedes construct very simple compound engines, in which the two pistons connect to opposite cranks,—steam being distributed by a single slide-valve arranged between the cylinders.

Messrs. Wm. Cramp and Sons, of Philadelphia, Pennsylvania, exhibited two marine engines, one a vertical engine of moderate size, the other a tastily designed vertical compound engine of the intermediate receiver type, with cylinders 16 and 28 inches in diameter, with 24 inches stroke of pistons. This engine had a steam reversing engine directly connected to the link operating the shaft, the valve of which received a differential motion derived from the hand-lever and the piston-rod, whereby the latter was, by the action of the steam, forced to move coincidently with the former. The device is claimed by *Engineering* (London) to be a modification of Mr. J. McFarlane Gray's steering-gear arrangement. The writer first saw it about the year 1868, in the United States steamer *Algonquin*, the machinery of which was designed by Mr. E. N. Dickerson, and has used a similar device several times since. The Davey differential valve-gear, for pumping engines, is very similar, a cataract engine being used to impart the motion applied in this case through the hand-lever.

Messrs. Neafie & Levy, of Philadelphia, Pennsylvania, had in operation, in Agricultural Hall, one of the vertical engines used for steamers of moderate size.

Models of engines for use on monitors and mortar-boats were exhibited by the Navy Arsenal, Brazil, and a number of complete models of ocean steamers and vessels for war purposes contained complete models of the steam machinery.

The models exhibited by Messrs. John Roach & Son, of Chester, Pennsylvania, also of New York, were particularly interesting. They included a beautiful model of an American beam engine complete in every detail, and model engines of a United States iron-clad in actual operation by steam in the model hull.

Mr. F. E. Sickles, of the Providence Steam-Engine Company, Providence, Rhode Island, exhibited original models of some of his early inventions. In his steam steering gear the eccentric operating the valves of the engines is revolved on the shaft by the hand steering-wheel, the engines following with substantially the same velocity. The Sickles trip cut-off, patented in 1842, with improvements, patented in 1845, furnished a very simple and efficient means for utilizing the expansion of steam with poppet-valves such as are used on American beam engines, and at an early date had the effect to draw the attention of engineers and steamship-owners to the importance of the general subject. A dash-pot was provided to arrest the fall just before the valve reached its seat, so that the suppression of steam could be made very promptly, in fact, so as to show a definite angle, instead of a curve, at the point of cut-off on an indicator diagram. In the original plan the valves were tripped by their own motion in lifting, afterwards by their own motion either in lifting or closing, but by a still further improvement they were tripped by an independent movement at any point of the stroke. This arrangement may be seen on many steamers, notably on the *Bristol* and *Providence*, the large steamers of the Fall River line, between New York and Boston.

The Stevens long-toe cut-off was introduced about the same time as the Sickles cut-off. This device lowers the valves at the same speed they are raised, and is much used on account of its simplicity.

The simplest form of trip cut-off yet devised is probably that applied to the beam engines of the Pacific Mail Steamship Company's side-wheel steamers, also to the steamer *Newport*, of the Fall River line, above mentioned, by Mr. Horatio Allen, when president of the Novelty Iron Works, New York. In this arrangement the lifters operating the toes on the valve-stems are each pivoted to the rock shaft and lifted by the end of a steel bolt in an arm secured to the shaft,—the bolt being pushed back at the proper time to release the lifter by a projection on a curved adjustable tripper. The fall of the lifter is controlled by a fluid in a chamber. The operating eccentric passes its extreme movement but a little in advance of the crank, so that the cut-off is adjustable for nearly the whole length of the stroke, a separate eccentric being provided for the exhaust-valves as in the Stevens arrangement. The system developed by Mr. Allen, of pivoting both parts of the disengaging apparatus on the same centre so as to insure a direct instead of a rolling contact of the disengaging surfaces, was at a latter date applied to Corliss valves on marine engines by Mr. George H. Reynolds.

STEAM-ENGINE INDICATORS.

The original form of the steam-engine indicator as invented by Watt, in which the steam-piston had the same movement as the pencil, was found inapplicable for use at high speeds on account of the momentum of the moving parts, which caused large vibrations of the pencil on the paper, and often serious jars with corresponding inaccuracies in the diagrams. In instruments on this plan it was necessary also to take hold of the pencil when in rapid vibration, in order to apply it to the paper. The first indicator adapted for high speeds was that used by Mr. Gooch, of England, for experiments with locomotives, in which the indicator piston was connected with the short arm of a lever and the pencil carried at the end of the long arm. This arrangement permitted the use of a stiffer spring, and reduced the vibrations within moderate limits. The objection was that the diagrams were distorted by the motion of the pencil in an arc of a circle, and particular care was required in measuring them.

In 1862 an important improvement was made by Mr. Charles B. Richards, of Hartford, Connecticut, who applied a simple parallel motion, in place of the single lever of the Gooch instrument, and thereby obtained the ordinary form of diagram with reduced movement of piston. The levers were pivoted

to a swinging arm, whereby the pencil could be moved up to the paper without handling vibrating parts. The Richards instrument finally came into general use to the practical exclusion of the old direct forms, and has proved of the highest value to engineers, assisting them in investigations for the purpose of improvement and enabling the performances of all kinds of engines to be satisfactorily compared.

The Thompson indicator, exhibited by the Buckeye Steam-Engine Company, of Salem, Ohio, is a modified form of the parallel motion, or Richards indicator, in which a simpler form of parallel motion is used than that employed by Mr. Richards. The construction still further reduces the momentum of the working parts without apparently introducing any objectionable features.

STEAM-GAUGES.

Steam-gauges were exhibited by the well known firm of Schäffer & Budenberg, Buckau, near Maydeburg, Germany; by C. W. J. Blancke & Co., Merseburg, Germany; by Messrs. Lion & Guichard, of Paris, France; by E. H. Ashcroft, of Boston, Massachusetts; the Utica Steam-Gauge Company, of Utica, New York; the Buffalo Steam-Gauge Company, of Buffalo, New York; and the Cleveland Steam-Gauge Company, of Cleveland, Ohio.

A gauge for water-works, with 30-inch dial, was shown by Mr. M. B. Edson, of New York, who also exhibited the Edson automatic indicating, recording, and alarm gauge, invented by him. In this instrument the variations of pressure are recorded on a ribbon of paper, kept in motion by an excellent clock movement, and are indicated also by a hand on a dial in the usual way. The tripping-post of the mechanical alarm (at top of the instrument) being insulated, and forming a negative—whereas the instrument is positive—provides a means whereby an electric circuit may be closed whenever the steam (or water) pressure shall exceed any given limit, which is valuable as a precautionary measure, and the records are secured by lock and key. The paper ribbon is printed with graduations and figures, which enable the pressure to be read that obtained at any given time. The instrument can be applied to record any changes of pressure, and be located in a private office at a considerable distance from the boiler or source of pressure. The gauge is valuable to show the attention paid by watchmen, firemen, and other employees to their duties either by day or night, or both, and the records may be made the basis of instructions to secure important economies in management. The instruments are being widely introduced, and their reliability and accuracy were satisfactorily shown during the boiler trials made by a Committee of the Group, the report of which is hereto appended.

GOVERNORS.

Time and space will not permit detailed reference to a number of interesting steam-engine governors, foreign and American. There were several new forms in the German, Russian, and Swedish departments, most of which were evidently based upon careful mathematical consideration of the principles involved.

AIR AND GAS-ENGINES.

The Rider air-engine exhibited by Messrs. Rider, Wooster, & Co., of Walden, New York, was quite interesting. It consisted simply of two connected cylinders, one the cold cylinder or air pump, the other the power cylinder, with their respective pistons, each connected to a crank above on a rotary shaft. In operation, the air drawn into the cold cylinder is compressed, passed through a regenerator, where it receives its first increment of heat, and is forced into the heater, where, becoming thoroughly heated, the pressure generated acts upon the main piston, driving it upward. When the latter arrives at the top of its stroke the exhaust-valve is opened, allowing the air to escape into the atmosphere, and a fresh charge is taken into the cold cylinder and the operation repeated.

Interesting gas-engines were exhibited by Messrs. Mignon & Rouart, of Paris, France, and by the Gas-Motor Factory, Deutz, Germany. In the Langden & Otto gas-engines, manufactured by the latter company, the piston is detached from the load when the explosion takes place and moves rapidly upward in the cylinder, retarded only by the vacuum formed below it and the atmospheric pressure on the other side. During the return movement of the piston a pinion operated by a rack on the piston rod is, by an efficient arrangement, clutched to the main shaft, and the power stored up in forming the vacuum is applied to increase the velocity of the shaft. The governor regulates the frequency of the strokes,—the fly-wheel maintaining the motion during the intervals between them.

STEAM-ENGINE ECONOMY.

It has been proposed to compare the duties of steam-pumping machinery of all kinds by the calculated amounts of fuel required to furnish the heat in the steam used, on the basis that the boiler is capable of uniformly absorbing 10,000 heat-units per pound of coal consumed. It will be found convenient to compare the performance of all kinds of steam machinery on the same basis.

Ten thousand heat-units per pound of coal, with $\frac{1}{6}$ refuse, corresponds to the evaporation of 12·426 pounds of water on the standard basis, viz., at atmospheric pressure from temperature of 212° per pound of combustible. Such evaporation should be obtained in a boiler properly proportioned to burn ·396 of a pound of coubustible, or ·475 of a pound of coal, with $\frac{1}{6}$ refuse, per square foot of heating surface per hour. Ten thousand heat-units per pound of coal also corresponds to an evaporation of 8·99 pounds of water at 80 pounds pressure, 9·03 pounds at 60 pounds pressure, or 9·08 pounds at 40 pounds pressure, from a temperature of 100 degrees, in each case. This evaporation is higher than is usually obtained, but it is not considered too high for a basis of comparison. It represents an ultimate efficiency of only ($10{,}000 \times 100 \div 14{,}500 =$) 69 per cent. of the calorific value of anthracite coal, so that ordinarily more than ($100 - 69 =$) 31 per cent. of the heat in the fuel is carried to waste up the chimney. A still greater loss is, however, experienced in utilizing the steam for the purpose of work in the engine. The mechanical equivalent of one heat-unit is 772 foot-pounds, which, on the basis referred to above and at page 21, corresponds to a duty of 772 millions of foot-pounds per 100 pounds of coal. The most economical steam-engines, for instance pumping-engines of approved types, utilize in the steam-cylinder only about 130 millions on the same basis, equivalent to an ultimate efficiency of ($130 \times 100 \div 772 =$) 16·84 per cent. of the heat in the steam, and but ($16{\cdot}84 \times {\cdot}69 =$) 11·62 per cent. of the calorific value of the fuel. The principal reason for this is that the exhaust steam necessarily carries to waste the heat required to maintain it in a vaporous state at the tension due to the back pressure. This under the most favourable circumstances forms the larger proportion of the total heat of the steam and reduces the opportunities for securing economy within small limits compared with the theoretical limit, although the differences between the performances of different engines are great when compared one with another.*

* In view of discussions in progress at the date of writing on the proper details of a theoretically perfect steam-engine, it is proper to mention that in the year 1868 the writer designed and partially constructed a non-exhausting experimental engine in which the steam, after expansion in the cylinder, was to be circulated through another vessel, to withdraw the water due to the performance of work; the dry steam was then to be returned to the cylinder and compressed, which it was expected would require less power than the expansion would furnish, and sufficient steam only be received from the boiler to supply that condensed for work. A demonstration of the correctness of the principle only was intended, the power expected being so small that the experimental engine was to be connected to another to keep it in motion. Before the apparatus was completed the funds were diverted to objects of greater immediate necessity, and the subject is mentioned only as indicating the general principle upon which a theoretically perfect steam-engine may be constructed. See description of the apparatus in article on the "Theoretical Steam-Engine," *Scientific American*, Supplement, Aug. 18, 1877. See also Prof. Thurston's calculations on a similar subject in *Journal of the Franklin Institute*, Oct., Nov., and Dec. 1877.

To secure economy of fuel within the limits indicated, it is usual to employ the free expansion of steam of high pressure. In practice, however, the full benefit of expansion cannot be obtained on account of internal condensation, it being found that even in the best engines a much larger quantity of steam is used than is due to calculations based on the terminable pressure. Various reasons have been assigned for this, but it is now generally conceded to be due to the differences of temperature in the cylinder and the consequent transfers of heat to and from the metal walls. Some writers having expressed doubts that this was sufficient to account for the great condensation observed, the writer in the year 1866 made some experiments on the subject. Two small cylinders or chambers, without pistons, were constructed—one of glass, the other of iron—of exactly equal capacities, and carefully felted, each of which could in turn be connected with a valve operated regularly by an engine to admit steam from the boiler to the experimental cylinder, and permit it to exhaust to a condensing coil. The exhaust opened slowly at first and rapidly afterwards, so that the pressure in the cylinder would approximate that in an ordinary steam cylinder. The result was that the condensed steam from the iron cylinder was in nearly every case fully double that from the glass cylinder.* The apparatus was sufficiently compact to form part of that of an institution of learning, and showed that the cylinder is still a condenser, the same as before the days of Watt, and that his invention of a separate condenser only reduced the extent of the loss. Tyndall points out in *Heat as a Mode of Motion* that the small amount of moisture ordinarily contained in the atmosphere has 70 times the absorptive effect, in relation to latent heat, of dry air. Steam chilled by the performance of work, or by reheating the metal walls previously cooled during the exhaust stroke, contains minute suspended particles of water with a great capacity for heat, which almost instantaneously absorb that necessary for their re-evaporation from the surrounding walls, and this action is at a maximum when the exhaust takes place and all the heat absorbed is carried to waste. The live steam supplied to the cylinder must evidently reheat the surfaces as rapidly as the pressure rises to produce the dynamical effect, and a portion thereby become condensed, so that a much larger quantity of steam is required than that simply due to the volume at the point of suppression.

The want of full knowledge on this subject has caused great difference of opinion and consequent errors in design. One class of steam engineers considered only the calculated results due to expansion, based on theory as it was called, or the law of Mariotte simply, without allowing for the thermal conditions under which expansion must take place, and constructed engines so *large* as to defeat the object in view. Another more limited class considered the subject of cylinder condensation in too serious a light, and from the results of a few experiments at moderate pressures concluded that all the beneficial results could be obtained with a very moderate expansion, and on that basis constructed engines too *small* for economy. Evidently a correct theoretical discussion of the subject should include the thermal conditions under which the steam must do its work, and which will vary for every difference in steam pressure, in the quality of the steam, the ratio of expansion, the size or proportions of the cylinder, the speed of the piston, etc.

Means for securing economy in steam-engines may be divided into two classes, viz., those of a mechanical nature and those which influence the thermal conditions. As to the first, the necessity of securing tight pistons and valves, ample area of cylinder passages, reduced clearances, etc., are well understood, also the incidental advantages due to a certain degree of compression. Those of the second class act to reduce the cylinder condensation, and include high speeds of revolution, steam superheating, steam-jacketing, and the compounding of engines. High speed of revolution (which does not necessarily imply high piston speed, as generally understood) secures economy by reducing the time

* *See American Artisan*, March 8, 1871. The experiments mentioned in the text were followed up by others with engines of moderate size provided with cylinders lined with non-conducting materials, which gave economical results, but were not adapted for practical use on account of the brittleness of the vitreous materials used for linings.

in which the transfers of heat to and from the steam and inclosing walls must take place.*

Superheating the steam has experimentally proved effective for moderate rates of expansion, in which the original temperature required to maintain the gaseous condition of the steam to the point of release was not too high to prevent proper lubrication. Mr. G. P. Dixwell, of Boston, Massachusetts, has applied a thermometer to a steam-cylinder, by inspection of which it is possible to regulate the temperature so as to prevent injury to the metal surfaces. The great difficulty is, however, to secure a permanent and reliable superheating apparatus. Steam-jacketing has to a limited extent advantages of the same kind as superheating, and involves no serious difficulties in management. The jackets are most effective on long cylinders of small diameter. In experiments with United States revenue steamers, herein-after mentioned, the economy of a steam-jacket on a comparatively short cylinder was found to be 11 to 12 per cent.

Compound engines, in addition to advantages of a mechanical nature, in better distributing the strains and rendering more uniform the rotative efforts, serve also to reduce cylinder condensation by the distribution of the differences of temperature between two cylinders. The radiation to and from the steam and its inclosing walls increases more rapidly than the difference in temperature, so that the sum of the losses, when the difference of temperature is divided between two cylinders, is less than when it all occurs in a single cylinder. Moreover, the heat imparted to the exhaust steam by the metal of the first cylinder is available for work in the second, and the low-pressure piston acts as a screen between the high temperature in the small cylinder and the low temperature in the condenser.

It is still strenuously denied by many that greater economy can be secured with a compound engine than with a long-stroke single engine using the same steam pressure. There are coasting steamers of similar size running regularly in the United States using both types of engine, with, it is claimed, substantially the same results; but the boilers for the single engines are evidently the more economical, making an accurate comparison impossible. Strictly comparative experiments have, however, been made by Chief Engineer C. H. Loring, U.S.N., and the writer with engines of different kinds in the steamers of the United States Revenue Marine, and by the writer with some of those of the United States Coast Survey.†

The revenue steamers were of the same size and the boilers very nearly identical. In one steamer was a compound engine with steam-jacketed cylinders; in another a long-stroke, high pressure condensing engine (cylinder not jacketed); in another an ordinary low-pressure engine (cylinder not jacketed); and in still another a high-pressure condensing engine with a jacketed cylinder. The compound engine showed a saving of 12 to 16 per cent. compared with the best performance of either single engine when operated at the same steam pressure. It is believed that substantially the same differences will be found in all cases when equally good engines of both types are compared. The performance of a short-stroke compound engine may be equalled or even excelled by that of a long-stroke single engine, on account simply of the difference in clearance spaces and the superior efficiency of the steam-jacket in the latter case, but by making the compound cylinders in the same form they should still show an advantage. In practice, the economy of marine compound engines is greater than above-mentioned, for the reason that the high steam pressure is better maintained with them than by the engineers than when single cylinders are used with high rates of expansion, causing difficulties in management.

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* The value of this saving was determined by the writer for the Novelty Iron-Works, Mr. Horatio Allen, President, in the year 1868, and embodied in a series of tables showing the relative power and economy of different sizes of steam-engines, which tables were afterwards published by Prof. W. P. Trowbridge, the former Vice-President of the company.

† See article by the writer on "Compound and Non-Compound Engines," *Transactions, American Society of Civil Engineers*, vol. iii. p. 68, 1875; *Journal of the Franklin Institute*, Feb. and March 1875; *Engineering* (London), Jan., Feb., and March 1875; *Proceedings of Institution of Civil Engineers* (British), vol. xl. p. 292, and vol. xli. p. 296; also report of trial of United States revenue steamer Gallatin, *Journal of the Franklin Institute*, Feb. 1876, and vol. xxi., *Engineering*, 1876.

The following table shows the performance of one of the Leavitt compound beam pumping-engines, at Lawrence, Masachusetts, described in article on Pumping-Engines; also that of the engines of the *Rush*, one of the revenue steamers previously referred to in this article.

Approximate Steam Pressure.	Ratio of Expansion.	Diameter of small Cylinder.	Diameter of large Cylinder.	Strokes of Pistons.	Revolutions per Minute.	Piston Speed.	Mean Pressure referred to large Cylinder.	Indicated Horse-power.	Water per indicated Horse-power per Hour.
		Inches.	Inches.	Inches.		Feet per Minute.	Pounds.		Pounds.
90	13·5	18	38	96	16·27	260·3	22·15	196·4	14·02
70	6·22	24	38	27	70·84	318·8	24·48	266·6	18·38

The comparison is very interesting. In both engines the larger cylinders are of the same diameter, but the difference in the duty for which the engines were designed required great differences in other proportions and in all the details of construction. In the pumping-engine for use on land there were no restrictions as to weight and space, so a comparatively long stroke could be employed and the connexions made through a beam. The marine engine had, however, to be located in a small vessel, and was therefore directly connected and proportioned accordingly. Yet the long-stroke engine was run with so much expansion and at so slow a speed as to develop less power than the smaller one, and the latter was less economical on account of the lower steam pressure and rate of expansion and the relatively greater proportion of waste room in the cylinder, incident to the necessary use of ordinary slide-valves. The engine of the Rush was, however, more economical than the ordinary stationary compound engines used for manufacturing purposes, as the latter, according to published reports in the engineering journals, require the evaporation of not less than 20 pounds of water for each indicated horse-power. The Lawrence engine contains all well-known means for securing maximum economy of steam, and it is probable that few if any engines are working with greater economy in respect to the indicated power. The performance is, however, much below that given by calculation when all the conditions are taken into consideration, other than the slight distortion of the theoretical indicator diagram found in practice and the important loss due to cylinder condensation.

In an engine using a total pressure of (90+14·7=) 104·7 pounds, expanded 13·5 times in a cylinder, with clearances, etc., equal to ·02 of the displacement, the calculated cost of one horse-power per hour, or 1,980,000 foot-pounds, should be only 8·12 pounds of water evaporated from the initial pressure, on the basis that the curve of expansion is hyperbolic, and that the consumption of steam equals the volume at the initial pressure required to fill the cylinder to the point of suppression, plus that condensed for the total work. With a pressure of 100 pounds above the atmosphere, and an expansion of 20 times, there should be required on some basis the evaporation of only 6·00 pounds of water per indicated horse-power per hour. It is probable that the practical results obtained with the latter pressure and expansion would be little or no better than those from the Lawrence engine, on account of the greater cylinder condensation due to the increased expansion.

The above calculated performances, and the practical results obtained with engines and other steam machinery of various kinds, is shown in the accompanying table, in connexion with the relative efficiencies obtained by considering the heat-units in the steam and the calorific value of the fuel.

Number of Line for Reference.	Description.	Steam Pressure.	Ratio of Expansion.	Water evaporated per indicated Horse-power per Hour.	Comparative Results on Basis that 10,000 Heat-Units are imparted to Water per pound of Coal. See pages 11 and 53. Calculations based on a Temperature of Feed of 100°. Duty in millions of Foot-Pounds, per Indicator, per 100 pounds of Coal. Pages 11 and 53.	Relative efficiency, based on the Proportion utilized of the Total Heat of the Steam.	Relative efficiency, based on the Proportion utilized of the Calorific value of Anthracite Coal.	Net Effective Duty for lifting Water, in Millions of Foot-Pounds, per 100 pounds of Coal.
		2.	3.	4.	5.	6.	7.	8.
1	Calculated performance. Maximum.	—	—	—	772·0	1·00	1·00	
2	Calculated performance (see page 744)	100	20	6·005	295·2	·382	·264	
3	Calculated performance	90	13·5	8·122	218·6	·283	·195	
4	Lawrence compound beam pumping-engines	89·4	13·7	14·019	126·7	·164	·113	
5	U. S. Revenue Steamer Rush,* compound-engine	69·2	6·22	18·384	97·03	·126	·087	
6	U. S. Revenue steamer Gallatin,* vertical cylinder with steam-jacket	67·2	4·19	21·48	83·08	·108	·074	
7	U. S. Revenue steamer Dexter,* vertical cylinder without steam-jacket	67·1	3·49	23·905	74·66	·097	·067	
8	U. S. Revenue steamer Dallas,* vertical cylinder without steam-jacket	32·0	3·13	26·945	66·91	·087	·060	
9	U. S. steamer Mackinaw,† inclined cylinder without jacket	49·0	2·2	30·306	59·16	·077	·053	
10	U. S. steamer Mackinaw, steam superheated	52·0	3·2	22·725	78·83	·102	·070	
11	Non-condensing engine, with governor cut off,‡ (steam-jacket)	81·7	5·0	25·482	69·81	·090	·062	
12	Non-condensing engines, regulated by throttle	—	—	—	30 to 45	·04 to ·06	·03 to ·04	
13	Pumping-engines							30 to 110
14	Steam-pumps. Large size proportioned for the work to be done							15 to 30
15	Steam-pumps. Small sizes for ordinary uses. See page 699							8 to 15
16	Vacuum-pumps. See page 699							3 to 10
17	Injectors when used for lifting water not required to be heated. See page 733							2 to 5

* See references in foot-note, page 743.
† See vol. ii., Isherwood's *Experimental Researches in Steam Engineering*, pp. 77-116.
‡ *American Institute Reports*, 1869-70, 1870-71.

TESTS OF STEAM-BOILERS.

HORATIO ALLEN, Esq., Chairman of Group XX., International Exhibition, 1876.

SIR,—We have the honour to transmit the following report of the trials of the principal steam-boilers used at the International Exhibition in Philadelphia.

§ 1. These trials were, at the request of the administration, conducted under the general direction of a committee of Judges of Group XX. The undersigned, who were selected by the Group as the committee for that purpose,

prepared instructions, which were issued by the administration to the exhibitors and others interested, in the latter part of August 1876, in an official printed circular, a copy of which is appended as Exhibit B.

§ 2. The experiments commenced on September 16, 1876, and were terminated November 11, 1876, the day after the close of the Exhibition. The records of the experiments, and cuts of the boilers, appear in the Report of the Bureau of Machinery, appended to the Director-General's Report. These, in connexion with the original records and drawings for comparison, and the statement of the assistant in charge, form the basis upon which this report is founded.

§ 3. The primary object of the trials was to enable the exhibitors to ascertain their standing in relation to one another, an opportunity for which, it is understood, had been promised by the Bureau of Machinery. The judges, in accepting the invitation to take charge of the matter, proposed what in the end should prove a more important object, viz.: to present to engineers and others interested a trustworthy record of experiments made with boilers widely different in type and proportions, from which the general knowledge of the profession in regard to the effect of known modifications could be enlarged, improvements made in rules referring to the subject, and manufacturers be enabled to adapt their proportions to the specific object to be accomplished.

The tests were made while the Exhibition was in progress, and the time was limited; so simple methods were necessarily adopted, but on as comprehensive a plan as seemed possible under the particular circumstances.

§ 4. Fourteen boilers were tested in the order named, viz.: the Weigand, the Harrison, the Firmenich, the Rogers & Black, the Andrews, the Root, the Kelly, the Exeter, the Lowe, the Babcock and Wilcox, the Smith, the Galloway, the Anderson, and the Pierce boilers.

A brief description of these boilers will be found in § 36 to § 49, inclusive.

§ 5. As provided in the instructions hereto appended, two tests, each of eight hours' duration, were made of each boiler; the first with full natural draft and clean fires, to determine the potential evaporation; the second with fires regulated to burn about three-fourths as much coal as before, or, in other words, to approximate average working conditions, with a view of ascertaining the economical evaporation.

Calorimetric observations of the quality of the steam were taken at stated intervals during all the tests, and have been considered in computing the results.

§ 6. The steam generated by the boiler undergoing test was utilized by being blown directly into the main steam-pipe connected with other boilers, and supplying the engines in the various buildings. The pressure in the boiler under trial was maintained at 70 pounds per square inch by regulating the stop-valve, an employee being detailed for the purpose, for whose observation a special steam-gauge was provided.

§ 7. Before beginning an experiment, steam was raised to 70 pounds, when the stop-valve was closed, fires hauled, and ash-pits cleaned. As soon as new fires could be established with weighed wood and coal, the water-level was noted (with fire-doors closed and fires burning), after which the stop-valve was opened; the time of opening the valve being recorded at the time of starting the test. After steaming for eight hours the stop-valve was closed and the water-level again noted (with fire-doors closed), the fires were then hauled and extinguished, and the ash-pits cleaned out.

§ 8. All the coal and kindling-wood estimated at its equivalent in coal, consumed for starting and maintaining new fires, were charged to the boiler, and all the water pumped into the boiler to maintain the level at the same height was credited to the boiler as evaporated, subject to corrections indicated by the calorimeter, as explained below.

§ 9. In the two tests of the Kelly boiler, the economy trial of the Exeter, and the economy trial of the Babcock & Wilcox boilers, the level at stopping was higher than at starting; and for those tests the amounts of water corresponding to the differences in level have been deducted from the amounts pumped into those boilers. In all other cases, however, the level at stopping

was the same as at starting, or when lower a few strokes of the pump would bring it up to the required point, the water thus pumped being of course credited to the boiler as having been evaporated.

§ 10. In all cases precautions were taken to trace all connexions to the boiler on trial, to see that they were tight; and all blow-off pipes were disconnected, so as to detect any leak that might occur through the blow-off valves. In two or three instances slight leaks occurred, but all the water was collected and deducted from the amount fed into the boiler.

§ 11. Before starting, the approximate amount of coal needed for the trial was weighed out of the coal-bin and dumped in a separate pile on the floor, away from all other coals. From this pile coal was taken in barrows as required for running the test, and the weight of each barrow-load noted. This plan of keeping two separate accounts of the coal removed all chance of error in the amount of coal actually consumed, as at the close of each experiment the two accounts were balanced, and any error would have been detected at once. The second coal account has been taken as the basis for calculating the evaporation, adding to it of course the equivalent of the kindling-wood, which was taken at the rate of 0·40 pound of coal per pound of wood.

§ 12. Upon completing a trial fires were hauled and extinguished as rapidly as possible, the grates and ash-pits carefully cleaned, and all the coal, ashes, and clinkers hauled from under the boiler were sifted. The coal was carefully picked by hand and weighed separately. This amount of coal deducted from the amount of coal fired on the grates gives the amount of coal actually consumed. By deducting from the latter the amount of refuse (ashes and clinkers) the amount of combustible consumed was determined.

§ 13. The feed-water measuring apparatus consisted of two metallic tanks placed on separate platform scales with provision for filling from the hydrant. A Blake double-plunger feed-pump, supplied with steam from the boiler on trial, was placed between the tanks, and its suction-pipe was provided with a rubber hose, whereby the pump could be made to take water at will from either tank. This pump was used on all the trials, and whenever it was attached to a new boiler precaution was taken to see that the feed-pipe was tight and that all other connexions of the boiler to other pumps or injectors were broken off.

After filling a tank with water from the hydrant, its gross weight was noted; and after it had been pumped out almost dry the suction-hose of the pump was shifted to tank No. 2 (previously filled and weighed), and the gross tare of tank No. 1 was taken; the difference between the gross initial weight and the gross tare being the net weight of water pumped into the boiler. Tank No. 1 was then refilled and its gross weight again noted, when it stood ready to supply the pump as soon as tank No. 2 should be emptied.

§ 14. The temperature of the feed-water was observed twice in each of the tanks. The measurements of the feed-water and the running of the pump were intrusted to one assistant. Another assistant had charge of the coal accounts, and also took half-hourly observations of the temperatures of the outside air, of the fire-room, steam, pyrometer, water-level, and steam pressure. This latter observation was taken from the gauge mentioned above, attached just below the stop-valve. A recording gauge was also attached to the boiler, and served to detect any negligence on the part of the man stationed on top of the boiler to regulate pressure. The barometic pressures given in the logs were not observed in the fire-room. Necessary data were kindly furnished by the Signal Station, U.S.A., and proper corrections have been made for level and temperature.

§ 15. The time was noted in every case when a tank of water was filled or a bucket of coal dumped. This is an important precaution, as, by observing the differences of time, it becomes impossible to omit or duplicate a record, which is not an uncommon accident in using a simple tally.

§ 16. The records of the temperatures of steam, as shown in the logs and given by a mercury thermometer, are undoubtedly too low. It was found when a draft was blowing over the boiler that, by simply covering the stem of the thermometer, the mercury would rise 10° or 15°. It will be observed, however, that, although the temperatures shown by the thermometer fall short of

the temperatures indicated by the calorimeter, the variations in both sets of records correspond.

§ 17. Anthracite coal from the Lea Colliery, Wilkesbarre, Pennsylvania, was used in all the trials, being the same as was supplied regularly to the Bureau of Machinery. It was nearly all uniform in size, and was taken directly from the pile without selection, so as to secure average working conditions. It proved to be of excellent quality, and, like many of the coals of the Wilkesbarre region, had an unusually low percentage of refuse for anthracite.

The two regular trials for economy and capacity were repeated with the Galloway boiler, using George's Creek bituminous coal of fair quality, that boiler being proportioned for the use of bituminous coal.

The firing was, in all cases, left to the judgment of the exhibitors.

§ 18. The percentages of refuse from the coal during the trials of different boilers are given in the following table, the quantities being modified slightly by the wood used in starting fires :

Designation of Boiler.	Percentage of Refuse from Coal.		Designation of Boiler.	Percentage of Refuse from Coal.	
	Capacity Test.	Economy Test.		Capacity Test.	Economy Test.
Wiegand	8·487	9·514	Lowe	10·640	11·286
Harrison	8·370	8·526	Babcock & Wilcox	7·842	10·997
Firmenich	8·629	10·338	Smith	9·311	11·133
Rogers & Black	7·868	9·836	Galloway	11·055	11·128
Andrews	9·428	10·319	Anderson	8·684	9·262
Root	9·674	10·485	Pierce	8·415	11·004
Kelly	8·676	9·009	Galloway (bituminous coal)	9·527	8,818
Exeter	9·254	11·405			

Calorimetric Tests.

§ 19. To determine the quality of the steam,—viz., whether it was moist, dry (saturated), or superheated,—portions were permitted to escape at regular intervals to a calorimeter, and employed to heat a known quantity of water. The general method has several times been employed for a similar purpose; but it was not thought necessary or practicable to use apparatus as delicate as that described by Professor Hirn (*Bulletin de la Société Industrielle de Mulhouse*, 1868–1869), or to condense all the steam, instead of utilizing it, on the more accurate plan developed by Professor Thurston (*American Institute Reports, New York*, 1871–72). The experiments were to be conducted at all hours of the day and night, and with the demand for celerity incident to the closing of the Exhibition; so it was considered advisable to use finely-graduated instruments of ordinary character, and depend for greater accuracy upon the well understood principle that the average of a large number of experiments practically eliminates errors not of a cumulative character, such as those arising from the want of unusually fine instrumental graduations.

§ 20. The calorimeter used consisted of a simple wooden barrel set on a platform scale,—arrangements being made whereby the barrel could be conveniently filled with cold water, and emptied by a cock at the bottom. A stirring apparatus was arranged in the bottom of the barrel, consisting of a small propeller operated by a handle on the top of a vertical shaft.

§ 21. The steam withdrawn from the calorimeter was in all cases taken from the vertical portion of the main steam-pipe nearest the boiler and just below the stop-valve regulating the delivery,—the connexion being made by means of a piece of small pipe inserted through one side of the main pipe and extending horizontally across the opening. The small pipe was $\frac{3}{4}$ inch in diameter, and provided with perforations of greater area than the pipe directed downward towards the current of steam. The outer end of the pipe was reduced to $\frac{1}{2}$ inch diameter by an inserted nipple, to regulate the velocity of the flow, and connected by $\frac{3}{4}$ inch gas-pipe carefully felted, having an ordinary $\frac{1}{2}$ inch

stop-valve at the end, to a hose one inch in diameter located near the calorimeter.

§ 22. In making an experiment, the initial weight and temperature of water in the calorimeter were observed, a little steam was blown to waste through the hose to heat the pipe, the hose was thrust into the water and the stop-valve opened wide, when the stirrer was operated and rapid observations of steam pressure noted, until the desired range of temperature in the calorimeter was obtained; then steam was shut off, the hose carefully removed and final observations of temperature and weight of water in the calorimeter noted.

There were twenty-four such experiments made during each trial, from which the quality of the steam may be obtained in the following manner:

§ 23. The water in the calorimeter of a known weight (W) is raised from the initial temperature (t) to the final temperature (t_1), so on the basis that the heat absorbed, expressed in heat-units, is measured by the difference in temperature (which is very nearly correct, as referred to hereafter), the number of heat-units imparted to the calorimeter is expressed by the product of the weight in pounds by the range in temperature $[W(t_1 - t)]$. This number of heat units is derived from the steam received from the boiler and condensed in the calorimeter, the weight $[w]$ of which is shown by the increased gross weight. This condensed steam imparts to the calorimeter: first its sensible heat, measured by its weight multiplied by the difference in the temperature of the steam $[T]$ due to the pressure, and that finally obtained in the calorimeter $[w(T - t_1)]$; second, the latent heat of the portion evaporated; and, third, in some cases, the superheat, which has raised the temperature of the steam above that due to the pressure.

§ 24. If from the total heat imparted to the calorimeter $[W(t_1 - t)]$ we subtract the sensible heat $[w(T - t_1)]$ of the water added, the remainder expresses the number of heat-units available for evaporation from the actual steam pressure, which result divided by the latent heat (l), due to that pressure, gives the number of pounds of water (x) which the heat in the steam is capable of evaporating at such pressure. Hence, using the symbols set forth above in the parentheses, we have—

$$x = \frac{W(t_1 - t) - w(T - t_1)}{l}.$$

§ 25. The quality of the steam (Q), when either moist, dry (saturated), or superheated, may be conveniently and clearly expressed by comparing the amount of heat it contains with that in dry or saturated steam. We have, then,—

$$Q = \frac{x}{w} = \frac{W(t_1 - t) - w(T - t_1)}{lw}.$$

When, therefore, the steam is moist the value of Q is a decimal which represents the proportion of the steam which was actually evaporated; for instance, if $Q = .95$, ninety-five hundredths of the apparent evaporation was actually evaporated, and the remaining five per cent. represents the moisture in the steam. When the steam is dry (saturated), $Q = 1$, and when steam is superheated, Q is greater than unity. In the latter case the excess represents the heat available for superheating, or the additional quantity of water which would have been evaporated had it been present. We thus have a basis of comparison for the quality of steam, whether moist or superheated, which expresses its comparative value under all conditions. For instance, the quality may be 95 per cent. or 102 per cent. of the standard, which is dry or saturated steam, which numbers represent accurately the quantity of water at a given steam pressure which the heat actually imparted would evaporate into dry steam of the same pressure.

§ 26. From the above we may derive also—

When $Q < 1$, percentage of water primed $= 100(1 - Q)$.

When $Q > 1$, number of degrees steam is superheated $= \frac{(Q - 1)l}{48} = 2{\cdot}0833l(Q - 1)$.

§ 27. Since the specific heat of steam varies slightly at different temperatures greater accuracy is obtained in making calculations by using tables in which this is taken into account, which has been done for the results herein-after set forth. The several experiments have been calculated separately, and the average based on the proportional quantities of steam withdrawn from the boiler for each experiment, compared with the totals of such quantities.

§ 28. The records in nearly all cases have been found to correspond well among themselves, only one case arising where any portion has been rejected for manifest inconsistencies. By the calorimeter records for the capacity test of the Exeter Boiler, it apparently required, in seven instances out of the twenty-four, ten pounds more steam to produce a given heating effect than in the other cases, thus showing in some instances nearly 70 per cent. priming, which is impossible, as no water would have remained in the boiler after a short time. Moreover, there is no gradation in the results, so the discrepancy is evidently due to an error of the assistant in reading the second figure on the scale, and represents a not uncommon experience among investigators. The seven records mentioned have been rejected in making the calculations, also the last similar one of the economy test of the same boiler, the logs, however, being retained in their original shape, so that others may draw their own conclusions.

Tables of Results.

§ 30. The results of the experiments are set forth in the tables,—§ 50–51,—and it is believed will be readily understood with little explanation.

§ 31. From the total quantity of water pumped into the boiler and apparently evaporated, line 21, the evaporation per hour, based on the actual amount of heat in the steam, line 22, has been ascertained for each trial by simply multiplying by the quantity expressing the quality of the steam, line 18, and dividing by the duration of the trial in hours, line 3.

§ 32. The evaporation during the several experiments took place at different pressures and temperatures, using fuel differing in amount of refuse, and consequently in calorific value. The water apparently evaporated per pound of the coal used is in each case given in line 24. In all subsequent lines the quality of steam has been considered. In lines 25, 26, and 27 the economical evaporations for all the boilers are compared on the same basis.

§ 33. Line 25 shows the water evaporated for each pound of the combustible portion of the coal at a steam pressure of 70 pounds from a temperature of 100°, from which the evaporation under other conditions may be conveniently obtained. Line 26 shows the evaporation per pound of combustible at atmospheric pressure from temperature 212°. This line has been prepared so that the results of the experiments may be conveniently compared with those obtained with other boilers at different pressures.

§ 34. Line 27 shows what we have termed the Commercial Evaporation, and represents, on a uniform basis for all the boilers, the quantity of water which each will evaporate under ordinary working conditions per pound of anthracite coal of average quality. The pressure of 70 pounds has been selected as representing fair average practice, and the evaporation will be little different for considerable differences in pressure. The temperature of feed has been assumed at 100°, as few boilers use cold water, and 100° is easily obtained with condensing engines, and is not greatly exceeded when inefficient heaters are used with non-condensing engines. When a temperature of 200° can be depended upon the commercial evaporation given would be increased 10 per cent., and proportionally for intermediate temperatures. For the purpose of comparison, anthracite coal is assumed to have $\frac{1}{6}$ refuse, which is as little as can be depended upon in ordinary practice.

§ 35. Line 34 shows the estimated Horse-Power of the several boilers, on the basis that the evaporation of thirty pounds of water is required per horse-power per hour, the results being derived from line 23, showing evaporation at steam pressure of 70 pounds from temperature of 100°.

Description of the Boilers.

§ 36. The Wiegand boiler consists of ten sections connected by one steam-drum and one feed-pipe; each section consists of a cast-iron tube-head, made in the form of a double pipe with connecting necks, into the bottom of which are screwed, in two rows of nine each, eighteen wrought-iron vertical tubes closed at their lower ends by cast-iron caps, each tube being 4 inches in diameter and 5 feet 4 inches long, including the cap. Within each of the tubes is arranged a smaller tube, resting at its lower end on the cap which closes the outer tube, and the upper end of the inner tube protrudes inside the tube-head, through and beyond a perforated baffle-plate. The cast-iron cap closing each outer tube is shaped so as to permit the free flow of water from the inner tube to the annular space between that and the outer tube. The heated gases striking the outer tube cause an upward current in the annular space, and consequently a downward current in the inner tube. The steam-drum is of wrought-iron, and its ends and those of the tube-heads are built in the brickwork and support the boiler. The grate is directly under the tubes; the flames and heated products of combustion rise vertically between the tubes and tube-heads; and, circulating round the steam-drum, half of which is superheating surface, pass to the chimney flue at the side.

§ 37. The Harrison boiler consists of eight sections or slabs built up of hollow cast-iron spheres, each 8 inches in outside diameter, connected by curved necks. The spheres are cast in groups of 2 and 4, and are connected by rebate joints. The groups are held together by bolts extending through the spheres and necks the entire length of sections, provided over caps at the end with external nuts. Each section or slab contains two rows of 12 spheres, four rows of 13, and two rows of 3, making 82 spheres to a slab. The slabs are connected to one feed-pipe and one steam-pipe by a series of short fittings and pipes with spherical joints forming a flexible connexion, which facilitates erection and permits expansion. Between the slabs and about at the water-line are placed horizontal cast-iron T bars, which prevent the direct action of the hot gases on the steam-heating surface. The slabs are set side by side at the angle shown, and are supported on suitable cast-iron rails or bars.

§ 38. The Firmenich boiler is provided with a central grate, at the sides of which are set in the brick-work two drums connected with two elevated drums by wrought-iron tubes 3 inches in diameter and 12 feet long, slightly inclined from the perpendicular, the ends of which are expanded in the drums. There are 50 of these tubes on each side, set in two rows, and arranged longitudinally in three divisions, located in different compartments of the brick-work. The first and larger compartment contains the grate from which the products of combustion pass upward, between, and along the tubes, and over the top of the compartment-wall; thence downward in two separate flue-shaped passages in the brick-work, along the second division of 12 tubes on each side; thence at either side through the bottom of the next compartment-wall and upward in rear flues along the last division of 4 tubes on each side. The currents from the two sides unite at the top and pass across the ends of the drums to the chimney. The lower drums are connected at the rear; the two upper drums are connected to a third central steam-drum by short necks. The whole boiler is inclosed in brick, as shown.

§ 39. The Rogers and Black boiler is composed of a vertical shell suspended over the grate by means of 4 wrought-iron brackets resting on the side-walls, and is provided with 72 external tubes, 2 inches in diameter, arranged vertically outside the shell in two circles; concentric therewith, the ends of the tubes being bent inward, as shown, and expanded in the shell. The products of combustion circulate around the shell and between the tubes, and escape at a side flue. On the top of the vertical shell is attached a horizontal steam-drum.

§ 40. The Andrews boiler is of the double return marine-tubular type, with external sheet-iron connexions for directing the products of combustion. The shell is rectangular with semi-cylindrical top. From the furnace, which is inclosed in the boiler, the products of combustion pass through short tubes, crossing rear water space to a lower compartment in rear connexion; return

through the tubes above the furnace and below the water-level to front connexion, and, making a second return through tubes in the steam-space, escape through the upper compartment of rear connexion to the chimney. This boiler was designed to obtain, in portable form, large power in small space, and had, it is understood, been frequently used in wrecking operations.

§ 41. The Root boiler consists of 160 wrought-iron tubes, 4 inches in diameter, and 8 feet 10 inches long, set in a group at at angle of about 20° from the horizontal, and inclosed at the top and sides in brick-work. Upon each end of each tube is screwed a cast-iron chamber, with small openings in the ends, and provided with a square flange. The several chambers are laid upon each other, so that the tubes are staggered, and the ends connected by hollow triangular caps, shaped so as to make shallow socked joints, packed with rubber round the openings. The caps are held in place by simple crow-feet. A steam-drum is attached to the boiler, and connected with the upper row of tubes by short pieces of 2½-inch pipe, the water-level being carried about 22 inches below them.

§ 42. The Kelly boiler consists of seven sections, connected to one feed-pipe and one steam-drum; in each section 10 wrought-iron tubes, each 3 inches in diameter, and 9 feet 9½ inches long, in two vertical rows of 5 each, are screwed in a cast-iron tube-head at the front, and incline slightly downward towards the rear, at which end they receive support, and are closed by caps. Diaphragm plates are set inside the tubes to secure circulation of the water therein. Above the water-line are secured shorter horizontal tubes, with rear ends closed, which are intended to superheat the steam. The main steam-drum, which is not exposed to the heat from the fire, is connected to a drum or water-heater located back of the tubes, inside of the walls. A return-pipe connects this drum to a main feed-pipe, joining the several sections.

§ 43. The Exeter boiler consists of hollow, rectangular, cast-iron, slab-shaped sections, set transversely, with twelve oblong openings in two horizontal rows through each section; there are 27 such sections, placed one in rear of the other, and connected through short side pipes to one steam and one feed-pipe, thus forming a complete boiler. Two of these boilers are placed side by side over one grate. The spaces between the sections are closed at the centre by horizontal partitions. The gases from the grate pass to the rear of the boiler through the lower rows of passages in the sections, and return through the upper rows, then pass to the rear again over the top of the sections, and escape to the uptake. The water-level is carried at about two-thirds the height of the sections; the steam-drum is not exposed to the heat. The feed-pipes of the two boilers are connected, but provided with independent checks and valves for shifting the feed.

§ 44. The Lowe boiler is an ordinary cylindrical tubular boiler, 4 feet in diameter and 18½ feet long, containing 46 tubes, each 3 inches in diameter and 15 feet long, with a chamber or connexion in the front end of the boiler, the rear of which forms the front tube sheet. The bridge-wall back of the grate is extended up to the shell. The heated gases pass through side openings, through water space, into the front chamber or connexion previously mentioned, thence through the tubes to the rear of the boiler, then in a return flue along the lower half of the shell to the rear of the bridge-wall, when they rise through two side flues, and, circulating around the upper half of the shell and a superheating drum, escape to the uptake.

§ 45. The Babcock and Wilcox boiler contains a group of 98 tubes, each 3½ inches in diameter and 15 feet 9 inches long, set at an angle of about 15° from the horizontal, in 14 horizontal rows, with 7 tubes in each row. The tubes in each vertical row are expanded at both ends in tube-heads to form sections, the heads being shaped to stagger the tubes. Openings are provided opposite each tube for cleaning. The sections are connected in groups of seven, at front and rear, to two horizontal drums. The water-level is maintained near the centre of these drums, and their lower portions are exposed to the heat. The two drums are connected by a horizontal steam-drum, as shown. Flanges on the tubes form a support for two fire-brick partitions, which, with the deflecting walls shown, cause the heated products of combustion to pass between the tubes three times before reaching the chimney-flue.

§ 46. The Smith boiler is an ordinary cylindrical fire tubular boiler, with additional heating surface applied by means of a setting. The bridge-wall is of cast-iron, hollow, and water-tight, and is connected with the feed-pipe. From the bridge-wall a set of pipes run horizontally under and back of the boiler, and connect through elbows to short vertical tubes screwed into a larger horizontal pipe located back of the shell and connected thereto. In addition to the above two cast-iron pipes run along either side of and below the grate, and are connected with the water-space in the shell. In the latter are attached on either side a series of vertical conical castings, bulb-shaped at their tops, with a small wrought-iron pipe in each as an outlet for steam, and the several small steam-pipes are connected together, and to the steam-space of the main shell.

§ 47. The Galloway boiler is constructed of steel, and consists of a shell 7 feet in diameter and 28 feet long. There are two grates located in cylindrical flues 33 inches in diameter and 7 feet 6 inches long. Beyond the grates the flues join in one elliptical flue extending to the rear of the boiler, and crossed by 30 vertical conical water-tubes known as "Galloway Tubes." The heated gases from the furnaces pass around the conical tubes and through the elliptical tube to the rear of the boiler, return to the front along the sides of the shell below the water-line, and, passing to the rear again under the centre, escape to the uptake.

§ 48. The Anderson boiler is composed of 14 sections connected together above and below the water-line. Each section contains 9 wrought-iron tubes 3 inches in diameter and 10 feet long, which are nearly horizontal and arranged in a vertical row. The four lower tubes are secured at their front ends to a cast-iron chamber and rise a little from front to rear. The front ends of the five upper tubes are similarly attached to an upper chamber, and slope a little from front to rear. The rear ends of all the tubes in each section are united by a manifold 3 inches in diameter. The lower front chambers are connected at their lower ends, and the front upper chambers at their upper ends. A vertical mud-drum is placed near the boiler front outside the brick-work, its lower end being attached to the lower or water-chambers, and its upper end to the steam-chambers. A steam-drum is attached on the top of the boiler outside of the brick-work. Slabs are so disposed as to form a partition above the 4 lower tubes of the several sections. The hot gases are therefore compelled to flow towards the rear end of the boiler in contact with the lower tubes, and to return in contact with the upper tubes nearly to the front end, where they escape to the uptake.

§ 49. The Pierce boiler consists of a cylinder revolved directly over the grate on suitable trunnions. The heated gases envelop the cylinder and enter one end of an annular row of tubes in the shell, and traversing the whole length of the boiler, return through another row of tubes concentric with the first, and escape to the chimney. Cups are secured around the tubes of the outer annular row to catch the water whenever the tube is lifted above the water-line by the revolving of the shell, and thus prevent overheating. The feed-water is introduced, and steam taken from the boiler, through the trunnions.

§ 50 A.—Results of the Capacity Trials of the Steam-Boilers.

1	Designation of Boiler.	Weigand. A	Harrison. B	Firmenich. C	Rogers & Black. D	Andrews. E	Root. F	Kelly. G
2	Date of trial - - - - - - - - - - - - - - - - 1876	Sept. 16.	Sept. 20.	Sept. 25.	Sept. 30.	Oct. 2.	Oct. 5.	Oct. 9.
3	Duration of trial - - - - - - - - - - - - - - - - Hours	8	8	8	8	8	8	8
	Average Pressures.							
4	Steam pressure in boiler above atmosphere - - - - - - - - - - - - Pounds	69·97	70·01	70·15	69·97	69·21	70·03	69·97
5	Atmospheric pressure - - - - - - - - - - - - - - - - - - Pounds	14·78	14·62	14·62	14·62	14·62	14·65	14·76
6	Total steam pressure - - - - - - - - - - - - - - - - - - Pounds	84·75	84·63	84·77	84·59	83·83	84·68	84·73
	Average Temperatures.							
7	Of external air - - - - - - - - - - - - - - - - - - - Degrees Fahr.	71·94	77·81	74·71	66·59	64·06	61·82	55·31
8	Of fire-room - Degrees Fahr.	90·93	91·00	91·17	78·65	79·35	72·59	83·91
9	Of steam - Degrees Fahr.	312·03	308·58	357·91	307·82	325·76	314·82	308·91
10	Of uptake - Degrees Fahr.	604·62	584·13	418·00	649·30	382·63	—	—
11	Of feed-water - - - - - - - - - - - - - - - - - - - Degrees Fahr.	74·13	71·33	68·92	65·80	66·54	63·71	61·26
	Coal, &c.							
12	Total amount of coal consumed, including equivalent of wood - - - - - - - - - - - - Pounds	5,366·80	3,309·60	1,865·70	2,135·10	1,834·90	4,346·70	3,596·20
13	Total refuse - Pounds	455·50	277·00	161·00	168·00	173·00	420·50	312·00
14	Total combustible - - - - - - - - - - - - - - - - - - Pounds	4,911·30	3,032·60	1,704·70	1,967·10	1,661·90	3,926·20	3,284·20
15	Coal consumed per hour - - - - - - - - - - - - - - - - Pounds	670·85	413·70	233·21	266·89	229·36	543·34	449·52
16	Combustible per hour - - - - - - - - - - - - - - - - - Pounds	613·91	378·07	213·08	245·89	207·74	490·77	410·52
17	Equivalent weight of coal per hour, with one-sixth refuse - - - - - - - - - - - - Pounds	736·70	453·68	255·70	295·07	249·29	588·92	492·62
	Results of Calorimetric Tests.							
18	Quality of steam. Heat-units in dry (saturated) steam being unity - - - - - - - - - -	·992	·979	1·005	1·024	1·021	1·023	·814
19	Percentage of moisture in steam - - - - - - - - - - - - - - - - - - -	·810	2·072	—	—	—	—	18·566
20	Number of degrees superheated - - - - - - - - - - - - - - - - - - Degrees Fahr.	—	—	9·067	43·950	39·110	43·631	—
	Water.							
21	Total weight of water pumped in boiler and apparently evaporated - - - - - - - - - - Pounds	38,489·50	25,890·75	15,879·50	15,290·25	13,397·50	33,745·25	28,460·45
22	Water evaporated per hour, corrected for quality of steam - - - - - - - - - - - - Pounds	4,772·22	3,170·39	1,994·62	1,956·46	1,709·82	4,315·95	2,897·06
23	Equivalent evaporation per hour at steam pressure of 70 pounds from temp. 100° F. - Pounds	4,883·70	3,252·34	2,050·59	2,016·78	1,761·10	4,457·25	2,998·34
	Economic Evaporation.							
24	Water apparently evaporated per pound of coal from actual pressure and temperature - Pounds	7·172	7·826	8·511	7·161	7·301	7·763	7·914
25	Water evaporated per pound of combustible at steam pressure of 70 pounds from temp. 100° F., corrected for quality of steam - - - - - - - - - - - - - - Pounds	7·955	8·602	9·624	8·202	8·477	9·082	7·304
26	Water evaporated per pound of combustible at atmospheric pressure and temp. 212° F. - Pounds	9·145	9·889	11·064	9·429	9·745	10·441	8·397
	Commercial Evaporation (see § 34).							
27	Water evap. per lb. of coal, with one-sixth refuse, at pressure of 70 lbs. from temp. 100° F. Pounds	6·629	7·168	8·020	6·835	7·064	7·568	6·087
	Rate of Combustion.							
28	Consumption of coal per hour, Coal assumed, with one-sixth refuse. } Per square foot of grate-surface - - - - - - - - - - - - Pounds	17·540	19·725	16·593	14·054	13·533	14·022	17·914
29	} Per square foot of total heating surface - - - - - - - - - - - - Pounds	·550	·504	·248	·738	·492	·368	·775
30	} Per square foot of least area for draft - - - - - - - - - - - - Pounds	147·339	69·370	85·232	—	132·600	116·850	120·741
	Rate of Evaporation.							
31	Water evaporated from 70 pounds pressure and temperature of 100°. } Per square foot of grate-surface - - - - - - - - - - - - Pounds	116·278	141·406	133·069	96·037	95·608	106·125	109·031
32	} Per square foot of total heating surface - - - - - - - - - - - - Pounds	3·646	3·610	1·989	5·045	3·478	2·789	4·718
33	} Per square foot of least area for draft - - - - - - - - - - - - Pounds	1,176·739	497·300	683·530	—	936·755	884·375	734·887
	Estimated Horse-power.							
	[illegible] and temp. 100° F. - -	162·79	108·41	68·35	67·23	58·70	148·58	99·94

1	Designation of Boiler.	Exeter. H	Lowe. I	Babcock & Wilcox. J	Smith. K	Galloway L	Galloway Bituminous Coal. L	Anderson. M	Pierce. N
2	Date of trial - - - - - - - - - - - - 1876	Oct. 12.	Oct. 14.	Oct. 18.	Oct. 21.	Oct. 26.	Oct. 31.	Nov. 7.	Nov. 10.
3	Duration of trial - - - - - - - - - - - Hours	8	8	8	8	8	8	8	8
	AVERAGE PRESSURES.								
4	Steam pressure in boiler above atmosphere - - - - - - - Pounds	70·00	70·00	70·00	70·21	70·09	70·18	70·00	70·00
5	Atmospheric pressure - - - - - - - - - - Pounds	14·82	14·55	14·62	14·58	14·66	14·73	14·58	14·62
6	Total steam pressure - - - - - - - - - - Pounds	84·82	84·55	84·62	84·79	84·75	84·91	84·58	84·62
	AVERAGE TEMPERATURES.								
7	Of external air - - - - - - - - - - - Degrees Fahr.	57·31	67·06	63·25	70·06	52·29	58·06	56·65	46·71
8	Of fire-room - - - - - - - - - - - - Degrees Fahr.	83·00	93·00	90·13	78·06	68·23	71·06	56·65	46·71
9	Of steam - - - - - - - - - - - - - Degrees Fahr.	306·00	308·65	305·44	309·62	309·88	310·18	320·47	310·88
10	Of uptake - - - - - - - - - - - - - Degrees Fahr.	438·12	359·71	472·81	435·06	322·18	383·00	534·00	455·62
11	Of feed-water - - - - - - - - - - - Degrees Fahr.	60·50	60·16	57·60	58·16	56·04	53·95	54·75	52·15
	COAL, &c.								
12	Total amount of coal consumed, including equivalent of wood - - - Pounds	3,290·50	1,898·50	5,407·00	3,190·10	3,699·70	3,285·55	4,191·70	2,071·20
13	Total refuse - - - - - - - - - - - - Pounds	304·50	202·00	424·00	297·00	409·00	313·00	364·00	174·30
14	Total combustible - - - - - - - - - - - Pounds	2,986·00	1,696·50	4,983·00	2,893·10	3,290·70	2,972·55	3,827·70	1,896·90
15	Coal consumed per hour - - - - - - - - - - Pounds	411·31	237·31	675·87	398·76	462·46	410·69	523·96	258·90
16	Combustible per hour - - - - - - - - - - Pounds	373·25	212·06	622·87	361·64	411·34	371·57	478·46	237·11
17	Equivalent weight of coal per hour, with one-sixth refuse - - - - Pounds	447·90	254·47	747·45	433·97	493·61	445·88	574·15	284·53
	RESULTS OF CALORIMETRIC TESTS.								
18	Quality of steam. Heat-units in dry (saturated) steam being unity - - - -	·952	1·005	·991	1·0035	1·006	·994	·997	·929
19	Percentage of moisture in steam - - - - - - - - - - -	4·808	—	·940	—	—	·624	·307	7·149
20	Number of degrees superheated - - - - - - - - - Degrees Fahr.	—	9·888	—	6·444	11·682	—	—	—
	WATER.								
21	Total weight of water pumped in boiler and apparently evaporated - - Pounds	26,278·75	15,959·75	43,535·75	28,817·00	30,680·75	28,998·75	30,704·75	16,805·50
22	Water evaporated per hour, corrected for quality of steam - - - Pounds	3,126·91	2,005·58	5,390·81	3,614·62	3,860·07	3,602·22	3,826·31	1,950·51
23	Equivalent evaporation per hour, steam pressure 70 lbs., from temp. 100° F. - Pounds	3,238·42	2,077·60	5,596·90	3,751·11	4,013·16	3,752·00	3,982·39	2,034·65
	ECONOMIC EVAPORATION.								
24	Water apparently evap. per lb. of coal from actual pressure and temperature - Pounds	7·986	8·406	8·052	9·033	8·293	8·826	7·325	8·114
25	Water evaporated per pound of combustible at steam pressure of 70 pounds from temp. 100° F., corrected for quality of steam - - - - - Pounds	8·676	9·710	8·986	10·373	9·756	10·098	8·323	8·581
26	Water evap. per lb. of combustible at atmospheric press. and temp. 212° F. - Pounds	9·974	11·163	10·330	11·925	11·216	11·609	9·568	9·865
	COMMERCIAL EVAPORATION (see § 34).								
27	Water evap. per lb. coal, with ⅙ refuse, 70 lbs. pressure, from temp. 100° F. - Pounds	7·230	8·091	7·487	8·644	8·130	8·415	6·936	7·151
	RATE OF COMBUSTION.								
28	Consumption of coal per hour. Per square foot of grate-surface - - - Pounds	14·930	11·310	16·797	17·359	13·711	12·386	15·949	11·381
29	Coal assumed, with one-sixth refuse. Per square foot of total heating surface - Pounds	·287	·338	·446	·376	·579	·523	·515	·814
30	Per square foot of least area for draft - - Pounds	104·164	129·173	83·050	133·920	61·624	55·665	53·162	245·294
	RATE OF EVAPORATION.								
31	Water evaporated from 70 pounds pressure and temperature of 100°. Per square foot of grate-surface - - Pounds	107·947	92·338	125·773	150·044	111·477	104·222	110·622	81·386
32	Per square foot of total heating surface - - Pounds	2·072	2·757	3·339	3·251	4·707	4·401	3·572	5·824
33	Per square foot of least area for draft - - Pounds	753·121	1,054·619	621·878	1,157·689	501·019	468·414	368·740	1,754·009
	ESTIMATED HORSE-POWER.								
34	On basis of 30 lbs. water evap. per H.P. per hour, 70 lbs. press., temp. 100° F. - Pounds	107·95	69·25	186·56	125·04	133·77	125·07	132·75	67·82

1	Designation of Boiler.	Wigand. A	Harrison. B	Firmenich. C	Rogers & Black. D	Andrews. E	Root. F	Kelly. G
2	Date of trial - - - - - - - - - - - - - - 1876	Sept. 22.	Sept. 21.	Sept. 26.	Sept. 30 and Oct. 1.	Oct. 3.	Oct. 6.	Oct. 9.
3	Duration of trial - - - - - - - - - - - - - Hours	8	8	8	8	8	8	8
	Average Pressures.							
4	Steam pressure in boiler above atmosphere - - - - - - - Pounds	70·03	70·03	70·06	70·30	70·06	69·94	69·95
5	Atmospheric pressure - - - - - - - - - - Pounds	14·74	14·87	14·50	14·63	14·59	14·47	14·71
6	Total steam pressure - - - - - - - - - - Pounds	84·77	84·90	84·56	84·93	84·65	84·41	84·66
	Average Temperatures.							
7	Of external air - - - - - - - - - - Degrees Fahr.	69·40	75·35	69·47	62·65	67·06	72·23	47·17
8	Of fire room - - - - - - - - - - Degrees Fahr.	85·53	95·94	83·59	73·88	83·29	88·35	84·24
9	Of steam - - - - - - - - - - Degrees Fahr.	313·17	310·76	356·17	309·76	328·47	312·50	310·00
10	Of up-take - - - - - - - - - - Degrees Fahr.	523·81	517·50	415·50	571·75	419·60	393·33	—
11	Of feed-water - - - - - - - - - - Degrees Fahr.	70·80	71·16	68·95	67·11	65·44	64·59	66·95
	Coal, &c.							
12	Total amount of coal consumed, including equivalent of wood - - - Pounds	4,151·55	2,275·30	1,482·35	1,453·80	1,185·90	3,053·90	2,380·95
13	Total refuse - - - - - - - - - - - - Pounds	395·00	194·00	153·25	143·00	122·38	320·20	214·50
14	Total combustible - - - - - - - - - - - Pounds	3,756·55	2,081·30	1,329·10	1,310·80	1,063·52	2,733·70	2,166·45
15	Coal consumed per hour - - - - - - - - - - Pounds	518·94	284·40	185·29	181·72	148·24	381·73	297·62
16	Combustible per hour - - - - - - - - - - Pounds	469·57	260·16	166·13	163·85	132·94	341·71	270·81
17	Equivalent weight of coal per hour, with one-sixth refuse - - - Pounds	563·48	312·19	199·36	196·62	159·53	410·05	324·97
	Results of Calorimetric Tests.							
18	Quality of steam. Heat-units in dry (saturated) steam being unity - - -	1·011	·991	1·018	·979	1·039	1·022	·944
19	Percentage of moisture in steam - - - - - - - - - -	—	·935	—	2·140	—	—	5·586
20	Number of degrees superheated - - - - - - - Degrees Fahr.	20·526	—	32·633	—	71·735	41·350	—
	Water.							
21	Total weight of water pumped in boiler and apparently evaporated - - Pounds	34,117·25	19,464·50	13,249·50	10,877·25	9,535·75	27,264·75	19,987·75
22	Water evaporated per hour, corrected for quality of steam - - - Pounds	4,311·74	2,410·29	1,685·27	1,330·56	1,237·96	3,483·89	2,383·89
23	Equivalent evaporation per hour, steam pressure 70 lbs., from temp. 100° F. - Pounds	4,425·40	2,473·13	1,732·42	1,370·12	1,276·55	3,594·96	2,429·21
	Economic Evaporation.							
24	Water apparently evaporated per pound of coal from actual press. and temp. - Pounds	8·218	8·555	8·938	7·471	8·041	8·928	8·393
25	Water evaporated per pound of combustible at steam pressure of 70 pounds from temp. 100° F., corrected for quality of steam - - - - - Pounds	9·424	9·507	10·428	8·362	9·602	10·520	8·970
26	Water evap. per lb. of combustible at atmospheric press. and temp. 212° F. - Pounds	10·834	10·930	11·988	9·613	11·039	12·094	10·312
	Commercial Evaporation (see § 34).							
27	Water evap. per lb. of coal, with ¼ refuse, 70 lbs. pressure, from temp. 100° F. Pounds	7·853	7·923	8·690	6·968	8·002	8·767	7·075
	Rate of Combustion.							
28	Consumption of coal per hour.) Per square foot of grate-surface - - - Pounds	13·416	13·573	12·937	9·365	8·661	9·763	11·817
29	Coal assumed, with one-sixth } Per square foot of total heating surface - Pounds	·421	·346	·193	·492	·315	·257	·511
30	refuse. } Per square foot of least area for draft - Pounds	112·696	47·735	66·453	—	84·856	81·359	79·650
	Rate of Evaporation.							
31	Water evaporated from 70 } Per square foot of grate-surface - - - Pounds	105·367	107·529	112·422	65·244	63·703	85·594	88·335
32	pounds pressure and temper- } Per square foot of total heating surface - Pounds	3·304	2·745	1·680	3·427	2·317	2·249	3·822
33	ature of 100°. } Per square foot of least area for draft	885·080	378·154	577·473	—	624·154	713·286	595·395

1	Designation of Boiler.	Exeter. H	Lowe. I	Babcock & Wilcox. J	Smith. K	Galloway. L	Galloway Bituminous Coal. L	Anderson. M	Pierce. N
2	Date of trial - - - - - - - - - - - - 1876	Oct. 12 and 13.	Oct. 14 and 15.	Oct. 18 and 19.	Oct. 21 and 22.	Oct. 27.	Nov. 1.	Nov. 8.	Nov. 11.
3	Duration of trial - - - - - - - - - - Hours	8	8	8	8	8	8	8	8
	AVERAGE PRESSURES.								
4	Steam pressure in boiler above atmosphere - - - - - - - Pounds	70·00	70·00	70·00	70·41	70·06	70·12	70·00	70·00
5	Atmospheric pressure - - - - - - - - - - Pounds	14·80	14·60	14·75	14·60	14·81	14·67	14·64	14·63
6	Total steam pressure - - - - - - - - - - Pounds	84·80	84·60	84·75	85·01	84·87	84·79	84·64	84·63
	AVERAGE TEMPERATURES.								
7	Of external air - - - - - - - - - Degrees Fahr.	44·81	56·12	41·00	62·93	50·65	71·65	55·13	49·23
8	Of fire-room - - - - - - - - - - Degrees Fahr.	84·06	84·76	86·81	75·94	70·93	78·18	55·13	49·23
9	Of steam - - - - - - - - - - Degrees Fahr.	308·00	309·00	289·06	311·00	310·06	310·06	322·75	312·94
10	Of uptake - - - - - - - - - - Degrees Fahr.	429·94	332·29	295·82	411·48	303·00	324·62	417·00	373·82
11	Of feed-water - - - - - - - - - Degrees Fahr.	68·93	66·44	63·98	61·79	55·95	55·12	54·00	53·20
	COAL, &C.								
12	Total amount of coal consumed, including equivalent of wood - - - Pounds	2,244·70	1,225·00	3,555·55	2,429·80	2,767·70	2,268·00	2,807·30	1,599·40
13	Total refuse - - - - - - - - - - Pounds	256·00	138·25	391·00	270·50	308·00	200·00	260·00	176·00
14	Total combustible - - - - - - - - - - Pounds	1,988·70	1,086·75	3,164·55	2,159·30	2,459·70	2,068·00	2,547·30	1,423·40
15	Coal consumed per hour - - - - - - - - - Pounds	280·59	153·12	444·44	303·72	345·96	283·50	350·91	199·92
16	Combustible consumed per hour - - - - - - - - Pounds	248·59	135·84	395·57	269·91	307·46	258·50	318·41	177·92
17	Equivalent weight of coal per hour, with one-sixth refuse - - - Pounds	298·31	163·01	474·68	323·89	368·95	310·20	382·09	213·50
	RESULTS OF CALORIMETRIC TESTS.								
18	Quality of steam. Heat-units in dry (saturated) steam being unity - - - -	·958	1·005	·973	·987	1·001	·997	1·008	·948
19	Percentage of moisture in steam - - - - - - - - -	4·165	—	2·670	1·306	—	·284	—	5·240
20	Number of degrees superheated - - - - - - - - Degrees Fahr.	—	9·457	—	—	1·411	—	15·668	—
	WATER.								
21	Total weight of water pumped in boiler and apparently evaporated - - Pounds	17,566·25	10,884·00	32,381·75	21,900·50	23,815·75	21,021·00	22,400·75	12,563·75
22	Water evaporated per hour, corrected for quality of steam - - - - Pounds	2,104·33	1,367·42	3,939·64	2,701·81	2,979·11	2,620·16	2,823·75	1,488·18
23	Equivalent evaporation per hour, steam pressure 70 lbs. from temp. 100° F. - Pounds	2,163·38	1,408·80	4,067·72	2,795·13	3,097·59	2,726·28	2,940·88	1,550·98
	ECONOMIC EVAPORATION.								
24	Water apparently evap. per lb. of coal from actual pressure and temperature - Pounds	7·826	8·885	9·107	9·013	8·605	9·268	7·979	7·855
25	Water evaporated per pound of combustible at steam pressure of 70 pounds from temp. 100° F., corrected for quality of steam - - - - - - - Pounds	8·702	10·371	10·283	10·356	10·075	10·547	9·237	8·717
26	Water evap. per lb. of combustible at atmospheric press. and temp. 212° F. - Pounds	10·041	11·923	11·822	11·906	11·583	12·125	10·618	10·021
	COMMERCIAL EVAPORATION (see § 34).								
27	Water evap. per lb. coal, with $\frac{1}{6}$ refuse, 70 lbs. pressure, from temp. 100° F. - Pounds	7·252	8·643	8·569	8·629	8·396	8·789	7·698	7·264
	RATE OF COMBUSTION.								
28	Consumption of coal per hour. Per square foot of grate-surface - - Pounds	9·944	7·245	10·667	12·956	10·249	8·617	10·614	8·540
29	Coal assumed, with one-sixth refuse. Per square foot of total heating surface - - Pounds	·191	·216	·283	·281	·433	·364	·343	·611
30	Coal assumed, with one-sixth refuse. Per square foot of least area for draft - - Pounds	69·374	82·746	52·742	99·966	41·270	34·698	36·379	184·051
	RATE OF EVAPORATION.								
31	Water evaporated from 70 pounds pressure and temperature of 100° F. Per square foot of grate-surface - - - Pounds	72·113	62·613	91·409	111·805	86·044	75·730	81·691	62·039
32	Water evaporated from 70 pounds pressure and temperature of 100° F. Per square foot of total heating surface - Pounds	1·384	1·869	2·427	2·422	3·633	3·198	2·638	4·440
33	Water evaporated from 70 pounds pressure and temperature of 100° F. Per square foot of least area for draft - - Pounds	503·112	715·127	451·969	862·699	386·704	340·360	272·304	1,337·051
	ESTIMATED HORSE-POWER.								
34	On basis of 30 lbs. water evap. per H.P. per hour, 70 lbs. press., temp. 100° F. - -	72·11	46·96	135·59	99·84	103·25	90·88	98·03	51·70

§ 52.—Governing Proportions of the Boilers Tested.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Letters for Reference.	Designation of Boiler.	Grate Surface.	Heating Surface.			Area for Draft between Heating Surfaces.	Ratio—			Water Space.	Steam Space.	Ratio Grate to Water Space.	Ratio Grate to Steam Space.	Height of Chimney above Grates.
			Water.	Steam.	Total.		Grate to Total Heating Surface.	Draft Area to Grate.	Draft Area to Total Heating Surface.					
		Square Feet.	Square Feet.	Square Feet.	Square Feet.	Square Feet.	Square Feet Heating Surface per Sq. Ft. Grate.	Square Feet Grate Surface per Sq. Ft. Draft Area.	Square Feet Heating Surface per Sq. Ft. Draft Area.	Cubic Feet.	Cubic Feet.	Cubic Feet Water Space per Sq. Ft. Grate.	Cubic Feet Steam Space per Sq. Ft. Grate.	Feet.
A	Wiegand	42·00	1289·70	49·67	1339·37	Between tube-heads - 5·00*	31·89	8·40	267·87	181·36	44·18	4·32	1·05	84·75
B	Harrison	23·00	627·00	274·00	901·00	Below T-bars 6·54* At rear - 8·5	39·17	3·52	137·77	54·09	23·72	2·35	1·03	84·75
C	Firmenich	15·41	1001·10	30·00	1031·10	1st contraction 6·86 1st flues - 6·49 2d contraction 7·50 2d flues - 3·00*	66·91	5·14	343·70	145·12	92·20	9·42	5·98	84·75
D	Rogers & Black	21·00	—	—	399·75	- - -	19·04	—	—	36·15	24·85	1·72	1·18	84·75
E	Andrews	18·42	288·04	218·36	506·40	1 - - 2·30 2 - - - 1·88 3 - - 1·88*	27·49	9·80	269·36	80·74	25·45	4·38	1·38	84·75
F	Root	42·00	1451·77	146·66	1598·43	1 - - - 9·45 2 - - 5·04*	38·06	8·33	317·15	116·68	45·69	2·78	1·09	84·75
G	Kelly (h. s. of ⅓ heater inc. -)	27·50	575·06	60·48	635·54	1 - - -12·44 2 - - 4·08*	23·11	6·74	155·77	58·17	27·97	2·12	1·02	84·75
H	Exeter	30·00	1005·06	557·94	1563·00	1 - - - 4·30*	52·10	6·98	363·49	83·77	44·60	2·79	1·49	84·75
I	Lowe	22·50	687·88	65·76	753·64	Openings in shell - 2·14 Tubes - 1·97* Side Flues - 1·80	33·50	11·42	382·56	140·18	50·90	6·23	2·26	84·75
J	Babcock & Wilcox	44·50	1676·32	0·00	1676·32	1 - - -16·63 2 - - 9·58 3 - - 9·00	37·67	4·94	186·26	229·00	137·85	5·15	3·10	84·75
K	Smith	25·00	1146·43	7·57	1154·00	Tubes - 3·24*	46·16	7·72	356·17	136·12	127·39	5·44	5·10	84·75
L	Galloway	36·00	852·54	0·00	852·54	Int. flue - 8·01* Side flues -10·67 Bot. flue - 8·94	23·68	4·49	106·43	562·91	169·12	15·64	4·70	89·50
M	Anderson	36·00	630·00	485·00	1115·00	Over Bridge -10·8 End of plate -11·0 Return - -15·7	30·97	3·33	103·24	66·90	55·75	1·86	1·55	70·00
N	Pierce	25·00	—	—	349·33	1 - - 1·52 2 - - 1·16*	13·97	21·55	301·15	20·11	43·11	·80	1·72	70·00

§ 53. The awards of the Judges were not based upon the trials; in fact, the latter were not commenced until the awards had been made by another committee of the same group. This report has been confined to a statement of what actually took place during the trials, without expressing opinions upon the all-important questions of the value, but more particularly the trustworthiness of the different mechanical details and arrangements employed by the various exhibitors. Many of these questions can only be settled by long practical use, under different circumstances as to management and the kind of fuel and water used.

§ 54. All the boilers of which tests were completed remained tight and in good working condition throughout except that one of the cast-iron caps on a tube in the Wiegand boiler cracked while a trial was in progress; after repairs, the entire trial was repeated.

A few slight leaks in some of the boilers were stopped before the tests commenced; and for one boiler, not herein mentioned, which could not be made tight, the tests were abandoned.

§ 55. The feed-water measuring-apparatus and the thermometers, including the fine thermometer needed for calorimetric observations, were loaned by Mr. Lloyd S. Wiegand, who evinced great interest in the experiments. Ashcroft's steam-gauges were employed, and were tested several times during the progress of the trials and found correct. Mr. Edson loaned one of his recording-gauges, which agreed perfectly with the other gauges, indicating even the small variations of pressure due to taking the calorimetric observations. Mr. Edward Marsland loaned one of his water-meters, which was used on the water-pipe from the hydrant to the measuring-tanks, and afforded a check on the weighing of the feed-water. The amount registered by the meter agreed within two per cent. with the amount measured in the tanks, the errors at times being as low as two-tenths of one per cent. Adams's shaking grates, used in the Firmenich, Root, and Babcock & Wilcox boilers, operated satisfactorily. The platform scales loaned by Fairbanks & Co. were tested before and after the experiments and found correct.

§ 56. Messrs. W. H. Weightman, A. R. Wolff, M.F., and G. C. Henning, M.E., assisted in making the final calculations herewith presented.

Very respectfully,

CHARLES E. EMERY,
CHARLES T. PORTER,
JOSEPH BELKNAP,
Committee on Boiler Trials of the Judges of Group XX.

TRIAL OF THE HOADLEY PORTABLE ENGINE.

HORATIO ALLEN, ESQ.,
Chairman Group XX., International Exhibition, Philadelphia.

DEAR SIR,—The following is a report of trials made by this Committee of the portable engine exhibited by the J. C. Hoadley Company, of Lawrence, Massachusetts, on the 17th of September 1876:

§ 57. The boiler is of the locomotive type, 16 feet long, with shell 40 inches in diameter. The upper plates are one-half inch thick, the lower ones three-eighths inch; the engine is secured to the top of the boiler, the upper plates being made heavier and stiffened to support the load. The cylinder is 14·56 inches in diameter and of 19·91 inches stroke, and is provided with a steam-jacket, serving also as the steam-drum of the boiler, and carrying the safety-valve. The main crank is double; the pillow-blocks on either side of it are made in one piece, with a saddle fitted upon and double riveted to the boiler, which saddle at its centre extends through an opening in the shell, thus giving clearance for the connecting-rod with the main shaft and cylinder at a reduced distance above the boiler. There are two balance-wheels, respectively 6 and 7 feet in diameter. The steam is distributed by Davis's patent piston-valve, made with considerable lap to obtain expansion, and operated by an eccentric, which is attached to a slide, and arranged so that its centre will be shifted at right angles to the direction of the main crank in a line advanced beyond the centre of the main shaft sufficiently to give the lead. The shifting is accomplished by a centrifugal governor attached directly

to the main shaft inside one of the balance-wheels, and consisting of weights controlled by elliptical springs. The motion imparted to the valve resembles that given by the stationary link motion.

§ 58. Previous to the trial steam was raised with fuel which was not weighed, the engine remaining at rest; the fire was then hauled out and renewed with weighed fuel, when, in due time, the engine was started, kept in operation for six hours and two minutes, when fires were again hauled, and all the remaining combustible credited. During the trial the water was weighed in the tanks, the revolutions of the engine noted by a register, and diagrams were taken every 20 minutes; the engine was controlled by a brake, which served also as a dynamometer, the indications of which were regularly noted. The brake consisted simply of iron bands surrounding one of the fly-wheels, faced inside with wooden blocks 3 by 5 inches, and provided with a tightening screw on one side and a lever on the other, to which were attached the weights and the usual regulating cylinder.

General Dimensions.

Engine.

Diameter of cylinder	14·56 inches.
„ „ piston-rod	2·375 „
Length of stroke	1·66 feet.
Capacity of clearances and passages in fractions of stroke	·091 „

Boiler.

Length of boiler	16·0 feet.
Diameter of shell inside	40·0 inches.
Length of fire-box inside	54·0 „
Width „ „	34·0 „
Height „ above grates (whole height 48 inches)	44·0 „
Number of tubes	80·0
Diameter of tubes outside	2·25 „
Length of tubes (between sheets)	113·0 „
Heating surface in fire-box above top of the grates	60·5 sq. feet.
„ „ „ tubes	394·5 „
„ „ „ smoke-box	6·5 „
„ „ aggregate	461·5 „
Area of fire-grate, 54 by 34 inches	12·75 „
Ratio of heating surface to fire-grate area	36·20 „

Results of Trial.

Duration of trial	6 hours 2 min.
Average steam pressure in boiler	124·61 pounds.
Average cut-off in fractions of stroke	·1765
Ratio of expansion	4·2
Average temperature of external air	65·89 deg. Fah.
„ „ „ engine-room	79·92 „
„ „ „ uptake	534·08 „
„ „ „ feed-water entering heater	73·00 „
„ „ „ „ „ boiler	183·00 „
„ „ „ steam	336·54 „
Total revolutions during trial	45,597·00
Average revolutions per hour	7,557·60
„ „ „ minute	125·96
„ initial pressure in cylinder, total	127·55 pounds.
„ „ „ „ to point of cut-off, total	122·34 „
„ final pressure in cylinder	27·64 „
„ total „ on piston	63·765 „
„ back „ „	25·275 „
„ net effective pressure on piston	38·49 „
Point of cushioning in fractions of stroke	·40

Indicated horse-power	80·29	
Dynamometer horse-power	72·72	
Power expended in friction of engine when loaded	7·57	
Power required to operate engine at its normal speed when unloaded, per indicator	5·80	
Total weight of feed-water pumped in boiler	12,404·5	pounds.
Average water per hour pumped in boiler	2,057·13	„
„ „ „ per indicator	1,555·97	„
Total amount of coal consumed	1,621·	„
Average „ „ „ per hour	268·67	„
Coal consumed per square foot of grate per hour	21·07	„
Refuse from coal	191·5	„
Percentage of refuse from coal	11·8	per cent.
Total combustible	1,429·5	pounds.
Combustible per hour	236·95	„
Water per indicated horse-power per hour by measurement	25·61	„
„ „ dynamometer „ „ „	28·27	„
„ „ total per „ „ „	15·47	„
„ „ indicated „ „ indicator	19·38	„
„ „ dynamometer „ „ „	21·40	„
„ „ total „ „ „	11·71	„
Coal per indicated horse-power per hour	3·35	„
„ „ dynamometer „ „	3·69	„
„ „ total „ „	2·02	„
Combustible per indicated horse-power per hour	2·95	„
„ „ dynamometer „ „	3·26	„
„ „ total „ „	1·78	„
Number of pounds of water evaporated per square foot of heating surface per hour	4·64	„
Number of pounds of water evaporated per pound of coal	7·65	„
Number of pounds of water evaporated per pound of combustible	8·68	„
Equivalent evaporation per pound of coal at actual steam pressure from temperature 212°	9·096	
Equivalent evaporation per pound of combustible at atmospheric pressure from temperature 212°	10·32	

§ 59. Preparations for the trial were made by Mr. J. C. Hoadley in consultation with the Committee. Two of the members of the Committee were present while the trials were in progress, and two of the assistants engaged for the boiler experiments were detailed to take the observations.

CHARLES T. PORTER,
JOSEPH BELKNAP,
CHAS. E. EMERY,
Committee of the Judges of Group XX.

EXHIBIT B.

MEMORANDUM OF INSTRUCTIONS FROM THE JUDGES OF GROUP XX., IN RELATION TO THE TESTS OF STEAM-BOILERS.

The trials to commence on the day of September. Two trials, each of eight hours' duration, to be made of each boiler, one at maximum power, with natural draft, with fires kept clean, but not otherwise forced; the other with damper regulated to burn three-fourths as much coal as before, to approximate average working conditions.

During the trials the coal and feed-water used are to be weighed, and quality of steam furnished ascertained, by means of a calorimeter.

All experiments to be made with anthracite coal of the same kind, quality, size, and condition.

Coal to be weighed in an iron bucket, on a platform scale. Weights to be fixed so that all buckets will contain same quantity. The tally to be checked by weighing from a quantity previously measured, or by dumping the several buckets at beginning of hour in separate positions on the floor.

During the trials a steam pressure of seventy pounds is to be regularly maintained on boilers by adjusting the safety-valve, to permit steam to escape, or a throttle-valve, to admit the same to main steam-pipes in building.

Before beginning an experiment, steam is to be raised with dry wood and allowed to escape from the safety-valve, with stop-valve closed; and, when there is a sufficient quantity of ignited wood on grates, coal fires are to be established with weighed coal, and, after fires have reached proper thickness, coal is to be supplied regularly, as to quantity and intervals of firing.

At the end of each trial the fires are to be hauled out and extinguished, and the combustible and refuse carefully separated and weighed when dry. In commencing the experiment, the feed-pump is to be worked just fast enough to maintain the water level at a mark on water-gauge, and when the pressure commences to fall below 70 pounds, on account of starting the coal fire, the feed-pump is to be stopped, height in glass noted, and immediately after safety-valve closed. Near the end of the experiment the stop-valve is to be again closed and safety-valve adjusted to blow off at 70 pounds, and when the pressure commences to fall below 70 pounds, on account of hauling fires, the above operations are to be repeated. The water pumped into boiler to maintain the level during the above interval will be held to have been evaporated by the coal burned, subject to correction by the results obtained with calorimeter.

Feed-water, measuring apparatus, and calorimeter to consist of two tanks: one, the measuring and calorimeter tank, to be set on a scale on a platform higher than the other and be provided with a stirring apparatus and with a cock to drain water into the lower tank, which latter is to be connected to feed-pump. The upper tank to be supplied with a specific amount of water (from 400 to 500 lbs.) through a hose, which water is to be heated by steam from boiler admitted through another hose one (1) inch in diameter, connected through a valve with a $\frac{3}{4}$-inch pipe placed inside the vertical outlet where steam finally leaves the boiler. Final weight with initial and final temperatures of water in measuring tank being noted, the water to be emptied into lower tank, and operation repeated. The temperature of water as fed to boiler to be determined from average in lower tank.

The steam pressures shown by an ordinary gauge to be recorded in logs, and a record of the pressure kept also by one or more approved recording gauges.

In addition to the above records, the temperature of external air, of fire-room, of the steam, and of the uptake to be noted; also reading of barometer and direction and approximate force of the wind. All records to be taken half-hourly, except in respect to calorimeter, which will be regulated by the demand for feed-water.

No boiler will be tested in a leaky condition or which has any connection which cannot be traced.

Drawings of the boilers tested are to be furnished by the exhibitors, sufficient in detail to enable the steam and water spaces, the heating surfaces, and draft area to be accurately ascertained.

Objections or suggestions as to the method of test or details of its management are to be submitted in writing for the action of the Judges, before the matter to be considered has been finally settled or concluded.

Trials to be made under the general direction of Messrs. Charles E. Emery, C. T. Porter, and Joseph Belknap, a committee of the Judges of Group XX. appointed for the purpose, and will be under the immediate direction of Mr. Hugentobler, who, with necessary assistants, will remain on duty throughout the entire duration of each trial.

A. T. GOSHORN,
Director-General.

Francis A. Walker,
Chief of Bureau of Awards.

TRIAL OF STEAM FIRE-ENGINES.

Philadelphia, October 10, 1876.

MESSRS. CHAS. T. PORTER, JOS. BELKNAP, E. BRUGSCH,
Committee Group XX. (Motors, Pneumatic and Hydraulic Apparatus).

GENTLEMEN,—About the 27th day of August I was notified that I had been appointed to take charge of the proposed trials of fire-apparatus, including especially steam and chemical fire-engines.

I have to report that the programmes agreed upon were printed, and a copy forwarded to each exhibitor, together with a letter inclosing a tracing for nozzle-pipe, with a request that one be made for each of the engines they proposed to work at the trial. The exhibitors were at the same time notified that they would be expected to furnish their own leading-hose and at least thirty-five feet of suction-hose, and that the ground on which the engines would stand was about seven feet above the water to be lifted. They were also notified that their engines would be numbered respectively in the order of their application for space at the Exhibition.

The numbering of the engines was as follows:—

Silsby Manufacturing Co., Seneca Falls, N. Y.	No. 1.
" " " "	No. 2.
B. S. Nichols & Co., Burlington, Vt.	No. 3.
La France Manufacturing Co., Elmira, N. Y.	No. 4.
J. D. Ronald, Chatham, Ontario	No. 5.
Clapp & Jones, Hudson, N. Y.	No. 6.
" " " "	No. 7.
L. Button & Son, Waterford, N. Y.	No. 8.
Amoskeag Manufacturing Co., Manchester, N. H.	No. 9.
" " " "	No. 10.
Clapp & Jones, Hudson, N. Y.	No. 11.

After notice to the exhibitors, the engines, except No. 11, were weighed on August 16, and all except Nos. 10 and 11 subjected to a hydrostatic test, in accordance with the programme.

This gave the basis for the pro-rata nozzles. No. 6 drew a stay-bolt and was slightly bilged in the fire-box; it was withdrawn for repairs, and again satisfactorily tested on August 29 to two hundred and forty pounds.

Those in charge of No. 9 asked for a working pressure of one hundred and fifty pounds, and an attempt was made to carry the test to three hundred pounds, but failed at two hundred and thirty on account of a leak in the upper part of the boiler. It was withdrawn for repairs, but not again tested, having been withdrawn before the trial began.

At first queries were raised by the builders as to the propriety of testing the boilers to double the working pressure, instead of fifty per cent. above, in accord with the "Government Rule." The answer was, that "the Govern-" ment boilers are not subject to so many strains,"—the extent of some of such strains being, from the nature of the case, unknown. This answer seemed satisfactory to all except No. 3, in which one hundred and fifty pounds was named as the working pressure, but the boiler leaked at two hundred and fifty-five pounds.

On Saturday, September 2, the Amoskeag Company withdrew their engines from the trial, not being satisfied with the conditions adopted for the government of the trials.

On the 4th of September all the engines except Nos. 9 and 10 took positions at the dock, and the day was spent in getting ready for the real work, which was to begin on the 5th. Two lines of leading-hose were laid from each engine, one being led from the discharge-gate to a small house, erected for the purpose, where the butt was capped and a pressure-gauge attached. The butts and gauges were placed in a row, so that all the gauges were brought under

the immediate inspection of Mr. W. F. Newell, who was appointed to record the water-pressures and time, and also to prepare and give out the blanks for steam-pressure and length of stream. To the butt of the other line the regulation nozzle-pipe was attached and secured to a frame placed on the Rider Life-raft Company's life-raft, so arranged that all the pipes were in the same plane and could be easily changed from one angle of elevation to another in a few moments. To avoid mistakes each pipe was numbered to correspond with the number of the engine to which it belonged. Mr. P. R. Voorhees was appointed by the Chief of the Bureau of Machinery, Chief Engineer J. S. Albert, U.S.N., to record the steam-pressures and to keep an account of the fuel used. Each gauge was numbered to correspond with the engine to which it was connected. On the table in front of each gauge was placed a sheet with blank spaces for recording water-pressures and time. Pressures were recorded every minute when any were indicated, and when no pressures were indicated zeros were used, and the added amount divided by the number of observations recorded during the trial. The coal and wood were weighed and furnished to the engines as required by the exhibitors, a strict account being kept of all furnished throughout the trials. The lubricating oil was furnished by Mr. F. S. Pease, of Buffalo, New York, of which an account was also kept.

The pro-rata nozzles were made of round disks of brass, in all cases two and a half inches in diameter and one quarter of an inch thick, to suit the regulation nozzle-pipes; the thickness being reduced to one-eighth of an inch at the orifice. These disks were made by Messrs. Pratt & Whitney, exhibitors in Machinery Hall; they also measured and marked the diameters of all nozzles used at the trials, and these are believed to have been perfectly correct.

The first trial commenced September 5, 1876. At 10 A.M. fires were laid with shavings, wood, and coal, with the understanding that no other combustibles should be used. All being ready, a signal was given to light torches, and at 11.16 A.M. the signal was given to light fires.

The pressure of water and steam maintained by each engine, and also the size of the pro-rata nozzles used at the different trials, is set forth in Exhibit B. The first trial ended at 12.08 P.M.

The second trial commenced at 2.35 P.M., September 5, with the medium nozzles. Engine No. 8 withdrew, having broken its pillow-block. For the work done by each engine, reference is made to Exhibit B. The trial ended at 3.32 P.M.

The third trial commenced at 3.48 P.M., September 5, the small-sized nozzles being used; observations of water-pressure being taken about once a minute throughout the trial. The trial ended at 4.39 P.M.

The sixth trial* commenced September 6, at 11.41 A.M. At 12 o'clock Engine No. 4 burst its air-chamber, and recorded but little pressure for the remaining thirty-eight minutes of the trial. No. 5 did not work satisfactorily, seldom indicating more than forty-five pounds pressure. The trial ended at 12.47 P.M.

The fifth trial followed trial No. 6 immediately without laying fires, commencing at 2.08 P.M., Engines Nos. 4 and 5 being still unable to work. The trial ended at 3.10 P.M.

The trial announced as the fourth, but made the sixth, commenced at 3.22 P.M., with the same conditions as in trial No. 1. Engines Nos. 4 and 5 made no record, having been disabled in the previous trial. Nos. 1 and 3 used a double line of leading-hose, terminating in one nozzle. The trial ended at 4.21 P.M.

The seventh trial was for vertical stream, and commenced at 10.13½ A.M., September 7, with large nozzles. Engine No. 4 was not ready until 10.44 A.M., but made a good record from that time to the end of the trial. No. 3 had several mishaps, and did not make a good record. The trial ended at 11.14 A.M.

The eighth trial was for vertical stream, and followed trial No. 7 without laying new fires; the nozzles were of medium size. Toward the end of the trial the suction-strainer of Engine No. 3 became clogged with grass that had been washed in from the lawn. An allowance has been made for this, giving

* The trials on September 6 were made in the order of 6, 5, and 4 of the programme, because the large-size nozzle of Engine No. 1, necessary for trial No. 4, could not at the time be found.

the engine a record for the trial equal to the best that it made during the play for an equal length of time. The trial ended at 1.07 P.M.

The ninth trial was for height and quality of stream, and commenced at 1.33 P.M., September 7, following trial No. 8 without laying new fires. The small-sized nozzles were used. The trial ended at 3 P.M.

The tenth trial commenced at 10 A.M., September 8. Steam-engines Nos. 1, 3, 4, and 7, Babcock Chemical Engine, No. 2, and Babcock Hook-and-Ladder Truck, No. 1, were the only ones reported ready with horses for the street trial. No. 3 finally declined, and the horses were sent away. The exhibitors laid fires to suit themselves. Each engine took on water, suction-hose, coal, tools, and four men; in fact, all they proposed to use in working the engines at the dock on their return.

The Babcock Chemical Engine, No. 2, was loaded with two tanks of water, chemicals for a half-hour's work on return, two hundred feet of leading-hose, ten feet of suction-hose, and three men. The engines were first trotted over the course to be run, and with the load so made up were weighed. On return it was found that No. 1 had been thrown off from one spring, which caused some delay in giving the word to start. It was claimed by Mr. Silsby that some extra pieces of rubber had been put under the bearing on the top of the ordinary spring, which had caused the derangement. The pieces were removed in about half an hour. One of the horses of No. 1 had cast a shoe, and as it was then after 12 o'clock it was determined to adjourn the run until 1 o'clock. At 1 o'clock the horses of Engine No. 1 had not returned, but the word was given to start. The order and time of starting of each engine and their subsequent return will be found in Table D. It will be observed that No. 1 left much later than the others, and made the run in about the same time as No. 7, and that Nos. 7 and 4 had in the meantime made a long record of pressures. It is to be remembered that it would have been perfectly fair to have given the word to start as soon as the weighing was done (which was originally intended), when the result would have been still worse for No. 1, so it cannot be unjust to take the record as it stands, and it has been so made up. The record made by the Babcock Engine, No. 2, will be found in the report on chemical apparatus, but it may be proper to state that it returned over 3.75 minutes ahead of all others, having started 0.25 minutes behind No. 7 steamer, and beaten it 3.75 minutes, and No. 4 by 8.25 minutes; it also commenced working 45 seconds after its arrival at the dock, being ahead of all competitors by 30 seconds.

It was found impracticable to continue the street trials on account of the inferior weight and quality of the horses and the long, heavy road through the grounds; one run seemed to exhaust their strength and endurance. The trial, therefore, continued at the dock until 3.41 P.M. It had been the understanding from the first day of the trial that the trials would be concluded on Saturday, September 9,* by a sweepstakes, in which the engines were to use any kind of nozzle and work at any pressure desired. As soon as the work was finished for the day, all parties interested were informed that such a trial would begin in the morning.

The Director-General, however, sent a request that the trials should come to an end that evening, on account of complaints of the smoke in the grounds and buildings. The trials proposed for the fifth day were therefore omitted.

Remarks on the Trials.

A careful analysis of the facts brought out at the trials will justify the theory upon which the programme and rules were made, viz., the engine that is capable, at a fire, of exerting the greatest amount of power in proportion to its weight (other things being equal) is the best. It is to be observed that all builders of steam fire-engines act upon this theory, whether they acknowledge it or not. Several of them have reduced parts of their engines to nearly the limit of the elastic strength of the material used when subject to predictable strains incidental to the steam and water pressures they are to employ, with-

* See rules for trial No. 13, Exhibit A.

out reference to the unknown shocks and strains to which machines of this kind are liable. It is true that there have not been many general catastrophes or explosions, but the bill of repairs has not always been as light as it ought to be. Again, all of the engines offered for competition make the boiler, more or less, the backbone of the whole structure. The bed-frame is bolted to it in all cases, and in Engines Nos. 3, 9, and 10 both the steam and water cylinders are made fast to the boiler. In Nos. 1, 2, 4, 5, 6, 7, and 11, the working strains do not affect the boiler, the carrying strains only being transmitted through the bed-frame.

These facts are not mentioned as condemning the method of fastening to the boilers, but to demonstrate, in a measure, the propriety of testing the boilers to double the working pressure. What has been said of boilers is true of all other parts of the engine, and if the builders so boldly cut down the weight of every item that enters into the construction of an engine, why should not weight be made the basis of classification? As stated above, the object of the trials has been to ascertain which engine, according to its weight, would do most work in a given time, and whether it is at the same time equal, superior, or inferior to its competitors in other respects that may be of importance in making up a good engine.

The pro-rata power of the different engines being decided, the one question that remains is, whether the engines exerting the greatest amount of power per weight were equal in other respects. To answer this question fairly and with perfect accuracy may at first seem difficult in the absence of facts that a thorough street trial would have established.

There are, however, enough data within reach upon which to base a practical and accurate conclusion. Take, as a starting-point, the engine that showed the best record, and compare the design, proportion, and manner of constructing its carrying parts with like features of other engines inferior in indicated power at the trials, viz.: 1st, wheels; 2d, axles; 3d, bed-frame; 4th, carrying-springs; 5th, boiler-hangings.

No. 7, the engine that has the best working record, is at the same time quite as strong in all respects (pro-rata to its work) as any of the engines, except the iron wheels on Nos. 1, 2, and 5. Therefore, No. 7 being the most powerful, and at the same time as strong, for street service, it remains to find where the excess of weight is in the engines of less pro-rata power. In comparing the different boilers, it is evident that Nos. 1, 2, 3, 4, 5, 8, 9, and 10 are heavier than Nos. 6, 7, and 11; this accounts for most of the excess of weight in the other engines. The question now remaining is, whether the boilers of Nos. 1, 2, 3, 4, 5, 8, 9, and 10 are as much better as they are heavier. A larger portion of the heating surface of the boilers of Nos. 3, 5, 8, 9, and 10 is made up of plates, and so these are necessarily heavier than those of 6, 7, and 11, where a larger proportion of heating surface is made up of tubes, while the boilers of Nos. 1, 2, and 4 are heavier because, though of the same general plan of construction as No. 7, they contain a much larger amount of heating surface. To decide this question it is necessary to consider what constitutes a good steam fire-engine boiler. The most important points may be stated as follows: 1st, strength; 2d, good circulation; 3d, sufficient super-heating surface to ensure dry steam; 4th, durability; 5th, accessibility for repairs; 6th, large area at water-line; 7th, a long range from low to high water; 8th, large flue area; 9th, non-liability to explosion.

The boiler of Engines 6, 7, and 11, is certainly equal to any other boilers in all respects. The boilers of Nos. 1 and 2 are heavier than those of 6, 7, and 11, only because they are larger.

The relative merits of construction were decided by making a list of all the parts that enter into the construction of an engine and considering each item by itself: 1st, as to general appearance, finish, and design; 2d, convenience for working; 3d, durability; 4th, strength and security; 5th, comparative excellence in arrangement; 6th, accessibility for repairs.

The value of each item was expressed by numbers from 1 to 10, which, added together, were divided by the number of observations made, and the average so obtained was entered in the general average account under the head of "construction marks." When one engine had an apparatus attached which another had not, the one that had such part was given an appropriate

mark, and that which had none received a zero. The comparative excellence of such parts as wheels, axles, bed-frame, braces, thickness of boiler-plates, staging and springs, has been determined by mathematical calculations based on measurement. When the pro-rata strength of the axles is considered, the boiler and bed-frame are in all cases treated as a beam having two points of support, varying in distance apart in the different engines. All the facts are summed up and expressed in what are called "construction marks."

As a further illustration of the methods of investigation, some of the facts relating to the hangings of Nos. 1 and 4 are given. In No. 1 the side-bars of the frame are five and one-half by three-fourths inches, fastened to the boiler by four bolts, with a lap on the boiler of seven inches; the bearings, one hundred and two inches apart, are strengthened by a brace from the boiler to the frame, leaving the frame at an angle of 23°.

The side-bars of No. 4 are five and seven-eighths by three-fourths inches, and are fastened to the boiler by six bolts and a lap on the boiler of fourteen inches, the brace leaving the frame at an angle of 28° and the bearings being eighty-nine inches apart.

Now, a simple statement of these facts makes it apparent that No. 4, as a beam, is the stronger; but No. 1 has the stronger axles; which is right? Three of the four bolts that fasten the side-bars of No. 1 to the boiler commenced leaking before the trial was finished, showing weakness or bad workmanship, or both. The above questions have all been settled, and the results go to make out the construction averages, making it unnecessary to construct more tables for this branch of the investigation.

The water-pressures indicated at trials No. 1 and 4 by Engine No. 1 show that there was a difference, although the nozzles were of the same size. The record of other engines shows a greater difference between them and No. 1 at the first trial than at any which followed. It was also noticed at the time of the trial that, although Engine No. 1 was working under a greater pressure than any other, its stream was inferior to several of them; this was particularly noticeable when the stream of No. 1 was compared with those of Nos. 2, 3, 4, 7, and 11, both as to quality and length of stream, while in several other trials it was superior in quality and length. After carefully comparing these facts, but one conclusion can be arrived at, that in trial No. 1 there must have been some unusual obstruction between the nozzle of Engine No. 1 and the working part of the pump, and that in justice to the other exhibitors the error should be corrected by striking out at least a portion of the average of No. 1 at the first trial. By the most careful examination that can be made, this excess cannot be less than fifty-three pounds, but the account has been made up by deducting fifty pounds. During the sixth trial Engine No. 1 drew the coupling off the leading hose next the engine, which caused a diminution of the record; but at the same time No. 7 was flooded by this accident to such an extent as to nearly extinguish its fire. No. 1 caused the accident, but suffered most; and as the contest was between these two competitors, and no others are practically affected by the mishap, no effort has been made to rectify the record.

Nos. 9 and 10 (Amoskeag) having been withdrawn from the trial, there is no record of work to compare with the other engines; and, as No. 9 is a self-propeller, it cannot be compared with the other engines if the theory upon which the trials is based is adhered to, nor has any more satisfactory method of classing them been proposed. No. 10 has the strongest wheels of any of the engines; the axles are about as strong, the bed-frame is among the strongest; the boiler is heavier than that of Nos. 3, 5, or 8, because thicker iron is used in its construction; it is heavier than that of Nos. 6, 7, or 11, because more plate-iron is used; and it is about the same weight with Nos. 1, 2, and 4, because the latter use more fire surface pro-rata to the entire weight of engine. By a careful analysis of its construction, size, and relation of water and steam cylinders, and the plan and capacity of the boiler, a tolerably accurate conclusion may be arrived at as to its relative merits compared with the other engines. The area of the steam-cylinder is nearly three times that of the water-cylinder, giving a much less capacity for forcing large quantities of water (other things being equal) than is possessed by the other engines in question.

The limit to the capacity of a reciprocating pump is the number of times the cylinder can be filled in a given period. The extreme limit is the velocity at which the water will follow the piston, taking into account the obstruction of valves and waterways and the number of times the direction of the water is changed in getting into and out of the pump, and also the angle at which the change is made. In making up the account the same rules have been applied as in the case of the engines that took part in the test, so far as construction is concerned. As to what was possible for Engine No. 10 to do in the way of working, it is clear that it could not have done better than No. 7. It probably would have indicated a higher pressure on the small stream, but not any better on the medium stream, and not so good on the large stream. The relation between the heating surface of the boiler and the steam cylinder, as well as the relation between the water and steam cylinders, should be considered in connection with the waterways, valves, number of revolutions per minute, and amount of water to be handled. Now, it is difficult to see the advantage that No. 10 could have over No. 7 as regards any stream but the smallest. Relatively to weight of boiler, it has not so large an area of valve-opening, its waterways are not so short and direct, the steam-cylinder is smaller, and the pump must run faster. It has also less heating surface.

The working parts of this engine are not as accessible for operating and repairs as several of the others; this is partly owing to the steam and water cylinders being placed vertically, which brings the fly-wheels directly in front of the working parts of the engine. The difficulties incidental to these arrangements have been in some degree obviated by an ingenious device for oiling. This consists of a large fountain or dish, so located that the oil is conducted through small tubes to the eccentric, cranks, crank-pins, slide-blocks, and main shaft-journals. The flow of oil is regulated by cocks that are more or less accessible when the engine is not in motion. Whether these inconveniences are compensated for by any advantages in the arrangements that create the necessity for such additional parts is another question that has been treated separately, the foregoing remarks being intended to apply to the subject of accessibility and convenience in working and adjustment. The reasons for placing the engine and pump in a vertical position are as follows: 1st, to allow the front wheels to interlock, so as to be able to turn the engine short; 2d, to secure steadiness while working; 3d, to shorten the steam connection.

The builder of Engines Nos. 6, 7, and 11 claims that, by transmitting the working strains of the engine through the centre of the bed-frame and counter-balancing, steadiness is more nearly attained, and that their steam connections are as short as in any other engine, and also that greater strength and security are obtained with much less cost for construction and weight of material.

The steadiness of No. 7 while working at the trials, and its plan of construction, show it to be equal to any in this respect, except the rotary engines.

The trials and measurements show that Engine No. 3 has a strong frame and axles, a large, heavy boiler, a very large area of grate surface, large steam and water cylinders, and long, variable water-line. These relations and conditions are favourable to throwing large, long streams for a short length of time, but not for continuously maintaining high pressures on long lines of hose or small nozzles, which is the same thing. The parts to be handled for working purposes are quite accessible, and for facility of repairs this is among the best of all engines.

Engine No. 4 is, in a general way, a strong, well-built rotary engine, but seems to have been put into the trial without the proper preliminary tests. The difference in the weight of this engine as compared with Silsby's No. 1 is accounted for in the greater thickness of the iron boiler-plates (Silsby using steel), and a somewhat heavier bed-frame, and some little difference in the working parts of the engine and pump. In stoking, too much coal was kept on the grate.

The general appearance of Engine No. 5 was good, and favourably impressed all interested in this kind of machine, but its record proved unsatisfactory. Early in the trial such serious defects were developed that those having it in charge found it impossible to keep it at work when wanted, although some hours were allowed each day for repairs. In the construction of this engine the builder has copied parts of several of the American engines: 1st, the

boiler and the details of the pump and engine are from the Amoskeag: 2d, the bed-frame and arrangement of steam and water-cylinders are a copy of the engine of Cole Bros., as is also the method of attaching the frame to the front axle; 3d, the wheels are from the Silsby Manufacturing Company. Many of the minor details are also a copy of other engines. There was something that was not copied, for either of the above-named engines habitually does better work than was done by No. 5 on this trial.

No effort has been made to decide whether rotary or reciprocating engines are the better, further than is determined by the record of the trials, and by a consideration of the one hundred and eighty-five points relating to construction.

Engine No. 8 has some features which differ from all others: 1st, the location of the steam and water-cylinders; 2d, the two capacities of the pump, which are obtained by working a small piston through a larger one or working both at the same time, the object being to use the large area on large streams and the smaller one on small streams, or long lines of hose. These cylinders are engaged or disengaged at will by an outside lever. It is certainly desirable to attain this double capacity, and the arrangement for the purpose is ingenious and effective; but the question whether it is not attained by too great cost and increased liability to get out of order is not quite so clear. It may be observed that this engine made a good record at the first trial previous to its break-down, and that the break was not owing to this arrangement. As to the first-named point, it may be said that by placing the engine and pump forward over the front axles, the wheels may interlock or turn under without adding so much to the length of the engine as in the case of the others, where the front wheels turn forward of the engines and not around.

Water-Pressure the true Test of Efficiency.

But little, if anything, can be learned of the merits of an engine from a consideration of the length and quality of stream. Certainly all that can be thus approximately learned can be definitely and accurately ascertained, and with less labour, by observing the size of nozzle used and the water-pressure maintained while the engine is worked.

The consideration of length and quality of stream was made a point in the programme, mainly for the purpose of clearly demonstrating the difficulty (it might be said, fallacy) of testing engines in this way. Pressure, other things being equal, determines the distance a stream should be projected The causes that affect a stream are mainly outside of the engine, and may be stated as follows:

1st. Kind of nozzle, good or bad.

2nd. Consideration of the column of water in leading hose, as it arrives at the nozzle, as to whether it has a spiral motion or not.

3rd. Whether or not the water has a pulsating motion.

4th. The condition of the air as to density.

5th. The direction and velocity of the wind.

6th. The size of the stream.

The simple statement of these points show how difficult it must be to form an accurate conclusion as to the comparative merits of engines, particularly if they vary much in size and plan of construction. A stream may be so small or a nozzle so bad, that no amount of pressure will throw it two hundred feet; while it may be so large and the nozzle so perfect that a very moderate pressure will throw it two hundred and fifty feet, while the small engine might be a good one and the larger one quite deficient in excellence. It is clear that all the points are chargeable to the engine; but one, the third, is caused by the engine, and nothing else. The absurdity of testing engines by length of stream was manifested throughout all the trials.

The course of the horizontal streams was along the margin of the lake, and except the first one hundred feet, was about parallel with it. Pairs of stakes were placed along the shore ten feet apart,—the shore-line parallel with the line of the streams, the outer line of stakes parallel with the first line and about twenty feet back from the margin, and so placed that the line drawn from one stake to its pair would be at right angles with the line of play. The distance

of each pair of stakes from the nozzles was so marked that the distance thrown by any engine could be constantly observed and recorded. The height of the vertical streams was determined by the use of the theodolite, located several hundred feet from the nozzles. An officer was detailed by Mr. H. J. Schwarzmann, Engineer of the Exhibition grounds, with two assistants, who were engaged for two days in observing and recording the facts relating to length of stream, and his results so obtained are set forth in the tables.

Each day there was some wind; and, though not very strong, it was of sufficient force to cause a variation of twenty-five to thirty-five feet in the longest streams, that could not be chargeable to anything else. A reference to the water-pressure, indicated and recorded as the time these variations were noticed, often contradicted the variations as regarding the stream of any engine so examined. The method of testing an engine through long lines of hose and length of stream is also imperfect, and some of the reasons why may be stated as follows, viz.: 1st, There is generally some difference in the smoothness of different makes of hose. 2nd. Some hose requires more pressure to force it out into a cylindrical shape than others. 3rd. One line of hose may have more or shorter turns than another. 4th. There is a liability to accidental obstructions, such as rags, strings, paper, straw, coal, gravel, &c. 5th. A spiral motion may be given to one stream of water and not to another, which would make a difference in the distance thrown, other things being equal.

Conclusion.

A careful analysis of the facts brought out at the trials, and calculations based upon actual measurements of various parts of all the engines in competition, afford sufficient data to warrant the following conclusion:

Silsby's No. 1 at all the trials did better than any of the rotary engines, and better than all the reciprocating engines, except Nos. 7 and 11.

Clapp and Jones's engines, Nos. 7 and 11, made the best record, and were the only ones, except Nos. 2 and 6, that went through all the trials without an accident sufficiently serious to interrupt their regular work. These (Nos. 7 and 11) are in most respects the strongest engines and the most perfect in detail and finish. It is also quite clear that No. 7 is superior to all others in nearly every point that concerns the making up of a good steam fire-engine. It has done better work than No. 1, has stronger axles, a stronger bed-frame, and is better secured to the boiler; it is more accessible for repairs, is as convenient to work; its wheels appear to be strong enough, and in workmanship and appearance it is equal, if not superior. It uses less oil and less fuel. The bed-frame of No. 1 is so arranged that the front wheels may be turned under, and it has iron wheels, which will be considered of more or less importance. An effort has been made to place a just comparative value on both of these points.

Chemical Engines.

With regard to the trial of chemical fire-apparatus, I have to report that the programme annexed was, on the 19th of August, forwarded to the different exhibitors of this kind of apparatus, together with a letter requesting them to make a nozzle-pipe after a tracing furnished them.

The engines were numbered in the order of their acceptance, as follows:—

Champion Fire Extinguishing Company	No. 1.
Babcock Manufacturing Company	No. 2.
W. K. Platt & Co.	No. 3.
Walton Bros.	No. 4.
Chas. T. Holloway	No. 5.

Preparations were made to furnish chemicals, and a place for the different exhibitors to build houses to be filled with combustibles, in accordance with the programme. The same theory was adopted for classing and testing as in the case of steam fire-engines; that is, the engine capable of taking the most extinguishing material to the fire with the least weight is the best, other things being equal.

The rules for testing were designed to decide, as far as possible, all the points involved, viz.: 1st, the weight of the engines, to be decided by

weighing them without any kind of supplies; 2nd, the relative amount of work that an engine could do, by playing each engine through a nozzle pro ratâ to its weight, the engine making continuous play through the largest nozzle being the best in that respect; 3rd, which engine could be soonest put to work on arriving at a fire; 4th, the comparative economy in the use of chemicals, to be ascertained by keeping an account of all the chemicals used and comparing the work with said account; 5th, the best mechanical arrangement for handling and carrying chemicals, best arrangement of engine for repairs, liability to derangement, and comparative excellence in adaptability to the largest range of circumstances in working at all kinds of fires, to be determined by a separate examination of every part of the engine, taken in connexion with the work done during the trials.

All exhibitors, in one way or another, signified their approval of the programme, but no one except the exhibitors of Engine No. 2 came forward at the day of the trial. The agent of the Babcock Manufacturing Company, Mr. Smith, said he was ready to do all and anything the Judges might direct, but if there was no competitor he would like to avoid the expense of putting up a building. It was decided that it was not a trial to prove the utility of chemical engines, but the comparative merits of the different builds, and that he need not build the house, but that the engine could go in competition with the steamers, and run with them on the street, and the time of starting, arriving, and working at the dock be noted.

It was worked sufficiently to show its capacity for keeping a continuous stream. It made better time on arriving and getting to work than any of the steamers, making it perfectly apparent to all who saw the performance that it could be taken over the ground at a much higher speed than a steamer, and that it could be brought into action on arriving at a fire in much less time.

To ascertain the comparative merits of the various engines, the same method of investigation was adopted as in the case of steam fire-engines, viz.:—

1. General appearance and finish.
2. Proportion of parts in relation to the whole engine as to strength and symmetry.
3. Accessibility of parts for working.
4. Accessibility of parts for repair.
5. Convenience in working and handling.
6. Comparative security in handling and carrying chemicals.
7. Certainty of quick action when wanted.
8. General adaptation to work under the greatest variety of circumstances.
9. Weight as per work done.
10. Character of driver's and other attendants' seat.
11. Character of liquid when in operation.
12. Regularity and continuity of stream.
13. Economy in use of chemicals, as shown by chemicals used and work done.
14. Amount of time required to get to work.
15. Amount of time required to charge.
16. Amount of time required to re-charge.
17. Non-liability to get out of repair.
18. Facility for repairing parts.
19. Arrangement for carrying signal-bell and operating the same.
20. Method of arranging and operating the brake.
21. Mounting and dismounting.
22. Amount of discharge-hose carried.
23. Convenience in winding hose.
24. Convenience in paying out or unwinding the same.
25. Number of men required to operate the machine in proportion to the work done.

Conclusion.

From a careful consideration of the foregoing facts and trials, it may be fairly concluded that the Babcock Engine, No. 2, is the best in most of the

points that go to make up a chemical fire-engine. Generally, it is the best arranged, is the lightest, has the best arrangement for handling chemicals, is most convenient for working, is most accessible for repairs, and is best adapted to a variety of work.

Respectfully submitted,

WELLINGTON LEE,
Expert.

GOULD STEAM FIRE-ENGINE.

The boiler of this engine is known as the vertical tubular with a submerged smoke-flue. The advantages claimed for it not found in other steam fire-engine boilers are: 1. The fire box is made tapering, giving an increased area of grate, which, added to the inclination of the sides of the fire-box over the fire, increases, it is claimed, the steaming qualities of the boiler without adding to its weight, while the water-leg, being larger at the top than at the bottom, gives a better circulation than if it were straight. 2. The smoke-box is conical in shape, and is made in one sheet; this form, it is said, gives the greatest strength, the best draft, takes up less room in the steam space, and makes one less joint in that part of the boiler most liable to leak. The steam-cylinders of the double engines are in one casting with the steam-chest opening on the front. In the single engines the steam-chest opens on the side, so that in either case it is easy to get at the valves when necessary. The eccentrics are forged solid with the crank-shaft, thus avoiding the liability of slipping, which is not an uncommon occurrence where they are not solid with the shaft. The pump consists of a casing, and a cylinder and valve-plate, the latter being in one casting of composition. By taking off the bottom cover of the pump, the valve-plate and cylinder can be dropped down, so that the valves can all be seen at once, and repaired if necessary, and the cylinder put back in place.

The arrangement of valves upon the vertical valve-plate, gives large area of suction and discharge with but little lift of valves. The valve-slides upon the stud are guided by knife-edged projections, which effectually prevent the valve from sticking up because of sand or gravel. The pump-packing is composed of leather, which is formed into a cup shape, there being two to each piston, placed back to back; the piston is thus self-packing, and with ordinary care is always ready to draw the water.

CLAPP & JONES STEAM FIRE-ENGINE.

The boiler is of the vertical kind, with both fire and water-tubes, the fire-tubes extending from the crown sheet of the fire-box up through the top of the shell, and the water-tubes being pendent from the crown of the fire-box. The outer rows of water-tubes extend nearly to the bottom of the fire-box, and surround rows of shorter tubes, which are about half the length of the outer row. In these tubes the water is isolated by means of diaphragms into thin films or sheets, so that the generation of steam will be very rapid,—the diaphragm serving to establish return passages for water to supply the place of that converted into steam and carried up by steam. By the arrangement of openings, much of the water lifted will be allowed to return to the return passage, without passing all the way up to the top of the tube.

The pump is so arranged that by taking off the heads (which can be done very quickly) the valves are taken out at the same time. This makes it convenient for repairs or cleaning out, if it should be required.

By introducing the water in the centre of the front head, the advantage is attained of an equal distribution of the water through the annular space to all sides of the pump-cylinder and valve-chambers, making a very free water-course to the valves. The further advantage is attained of retaining water enough in the pump to make sure of drawing water when first starting the engine, even on very high lifts, thus entirely avoiding the necessity of any connexion with the boiler for the purpose of "priming" the pump, or of providing any other means of doing what some fire-engine-builders and pump-makers have found it necessary to do, that is, to put water or grease into the pump either before or at the time of starting on very high lifts.

The air chambers are so placed on the pump, in connexion with the water-passages, that it will bear working at a very high speed.

Silsby Steam Fire-engine.

The boiler is of peculiar construction. It is vertical and both tubular and tubulous; *i.e.*, there is an extended heating and circulating surface of water-tubes, in addition to the ordinary smoke-flues. From the flue sheet hang circulating water-tubes, closed at the lower ends, and tightly screwed into the sheet. These tubes are inclined so as to best receive the heating action of the fire. Within each of these tubes is a light iron tube, down which the water passes after being heated by contact with the flues. Becoming highly heated and evaporated, the resultant steam escapes through the openings at the bottom, passes upwards through the annular space between the inner and outer tube, and becomes still further heated. Reaching the upper chamber it is further heated and dried by the smoke-flues. The boiler may be fed with cold water if desired, although a special heating apparatus enables the feed-water to enter the boiler from the tank at a temperature of 212°, resulting in great speed and economy in steaming. The boiler can also be fed directly from the main pump. The water-flues can be taken out and replaced in a few minutes; and the smoke-flues, being fastened from the crown sheet to the upper head of the boiler, are easily accessible by removing the dome, should repairs become needed, as it is not necessary to tear the boiler to pieces.

The engine consists of a pair of corrugated cams running together within an elliptical steam-tight case. The ends of the long teeth are packed by blocks of metal inserted into the grooves and pressed out by springs. These can be taken out and replaced in a few minutes by means of an opening in the sides of the case, preventing the necessity of taking the engine apart. The sides of the cams are turned to fit the case, and while steam-tight are so arranged that not only is due allowance made for contraction and expansion, but any little wear there may be, after years of service, can be easily taken up in a very short time.

The pump is on the frame in a line with the engine, and its construction is similar. Each cam in the pump has three long teeth instead of two, which insures a steadier motion. The packing is the same. The cams are fixed on steel shafts, which are coupled to the shafts of the engine. The action between the engine and pump is direct, the outside gears steadying the motion and equalizing the pressure.

EXHIBIT A.

General Programme of the Trials of Competing Steam Fire-Engines, and other Fire-Apparatus.

1. These trials will be four in number, and will take place on four consecutive days, commencing on the fourth day of September. On the first day the engines will be tested for capacity and endurance in delivering water through three different sized nozzles furnished by the judges, and varying in area for each engine, according to the weight, with boiler filled.

The second day will be devoted to trials for distance and character of stream.

The trials on the third day will be for height and character of stream.

These trials will be conducted on the grounds of the Exhibition, and each will be continued for three hours, and as much longer as the Judges may direct.

On the fourth day the engines will be tested by three runs over a course of at least a mile, to be fixed by the Judges; each run to be followed by a play of not less than thirty minutes, in which, with the exception of leading hose, nothing shall be used that has not been carried over the course. Engineer and all assistants must make the trips on the engines.

2. Bituminous coal will be used as fuel. Fuel, and whatever may be required to start the fire, will be weighed to each competitor.

3. All engines will play through at least one hundred feet of hose, but each competitor may play through whatever size or kind of hose, or through as many lines uniting in one nozzle, as he may choose. Each exhibitor will furnish his own hose.

4. Each engine will lift its water the same distance.

5. For the trials on the second and third days, each competitor will select his own nozzle. On each of these trials three nozzles shall be used by each one, varying in size from the smallest to the largest used by them on the first trial, respectively.

6. Pressure-gauges for water will be furnished and connected by the Judges.

7. The engines which are intended to compete will be weighed previously to the trial; first, without water or equipments; second, with boiler filled to proper working level; and, third, with equipments complete for service. Each competitor will fix his water-level as he desires, and will be required to start from such level on each trial.

8. No engine shall be ruled out on account of any accident, but shall resume work as soon as possible, and shall be credited with all work done within the time of trial.

9. Each competitor shall fix the highest steam-pressure at which his engine is to be worked, and this shall not be exceeded on the trials. All boilers and pipes will be subjected to a hydrostatic test of double the working pressure.

10. A detailed programme, with rules to be observed, will be furnished to competitors previous to the trials, in which provision will be made for trial of other fire-apparatus.

11. The trials will be conducted under the supervision of a Committee of the Judges of Group XX., consisting of Messrs. Chas. T. Porter, Emil Brugsch, and Joseph Belknap, assisted by Mr. Wellington Lee, of New York.

General Programme for the Trials of Competing Chemical and Preumatic Fire-engines and Apparatus.

1. These trials will commence on the sixth day of September, and, excepting the runs, will be conducted within the grounds of the Exhibition.

2. The trials will be four in number. The first trial will be for pressure and continuity of stream, through regulation nozzles, and for economy in the use of chemicals; and will be continued for half an hour, and longer if the Judges shall direct. The second trial will be for length of stream, for completeness of chemical combination at the first discharge, and for the promptness with which the apparatus can be brought into action. The third trial will be for efficiency in extinguishing fires. The fourth trial will consist of three runs over a course of at least a mile, to be fixed by the Judges, each run to be followed by a play of fifteen minutes.

The apparatus will be charged previous to the commencement of each run, and all equipments will be carried, and all attendants required to operate it must make the trips.

3. The engines will be weighed before the trials; first, without water, chemicals, or equipments; second, with one charge of water and chemicals; third, with water, chemicals, equipments, and additional chemicals sufficient for a half-hour's play.

4. Pressure-gauges will be furnished by the Judges, which are to be attached to the tanks by hose.

5. The Judges will have proper nozzles prepared for the first trial, varying in area for each engine, according to its weight, with one charge of water and chemicals.

6. On trial for length of stream, each competitor may use whatever nozzle he prefers.

7. All plays will be through at least one hundred feet of hose.

8. Chemicals will be furnished and weighed to the competitors as required by them.

9. Water for charging will be drawn from a tank or pond.

10. No engine will be ruled out on account of an accident, but will be credited with all work done during the time of trial.

11. A detailed programme, with rules to be observed, will be furnished to competitors previous to the trial; and in this programme provision will also be made for the trial of competing portable and stationary fire-extinguishers.

12. The trials will be conducted under the supervision of a Committee of the Judges of Group XX., consisting of Messrs. Chas. T. Porter, Emil Brugsch, and Joseph Belknap, assisted by Mr. Wellington Lee, of New York.

RULES TO BE OBSERVED AT THE TRIAL OF STEAM FIRE-ENGINES, TO BE HELD ON THE GROUNDS OF THE INTERNATIONAL EXHIBITION, COMMENCING SEPTEMBER 4.

1st. The engines will take up positions on the 4th of September at the dock in front of the north central entrance of Machinery Hall, so that everything may be in readiness on the 5th. Engines are not to be removed from their positions until required for the street test, unless for some unforeseen cause.

2d. Two lines of leading-hose will be attached to each engine, the one through which the playing is done to be furnished by the exhibitor; the other, leading to the Judges stand, to be furnished by the Judges, and to it are to be attached the water-pressure gauges.

3d. At least thirty-five feet of suction-pipe are to be used by each engine.

4th. The nozzle-pipes will all be secured to a frame, and will not need men to hold them.

5th. Wood and coal will be furnished by the Commission, but will be weighed and an account kept, and the facts so ascertained will be considered in making the general statement.

TRIAL No. 1 is the first of which any record is to be made, and will com mence on the 5th of September, at 10 A.M., and will be continued for at least one hour of continuous work.

a. The water in boiler to be cold.

b. The temperature to be ascertained and recorded.

c. Boilers filled to line agreed upon at the day of weighing.

d. Fires to be laid from wood and coal furnished by the Judges.

e. Largest size pro ratâ nozzle to be used.

f. All to start fires at a given signal.

Frequent observations will be made of the pressure of steam and water as soon as indicated, and the facts will be duly recorded.

TRIAL No. 2 will continue for one hour or more, at which the medium-sized nozzle will be used, and to follow No. 1 with as little delay as possible, without drawing the fires.

TRIAL No. 3 will be for one hour or more, at which the small or pressure nozzle will be used. To follow Nos. 1 and 2 without drawing the fires.

TRIAL No. 4 commences on the 6th of September at 3.20 o'clock P.M., and will be with large size nozzle to be furnished by exhibitor, but of same diameter as large pro ratâ nozzle used respectively at trial No. 1, and will be for distance and character of stream. Duration of trial, one or more hours. Boiler filled with cold water, &c. same as in trial No. 1.

TRIAL No. 5 will be for one hour or more, and similar to No. 4, excepting in this case a medium-sized nozzle will be used. To follow No. 4 without drawing the fires.

TRIAL No. 6 will be same as Nos. 4 and 5, excepting that in this case a small or pressure nozzle will be used. To follow No. 5 without drawing fires.

TRIALS Nos. 7, 8, and 9 will begin on the 7th of September, at 10 o'clock A.M., and will be for vertical stream, and in other respects similar to Nos. 4, 5, and 6, the exhibitors selecting the nozzles, but conforming as nearly as practicable to the three sizes of pro ratâ nozzles furnished by the Judges.

TRIAL No. 10.—*a*. Will be for playing at the dock and running on the street, and will commence at 10 o'clock, with new-laid fire, &c. same as trial No. 1.

b. Each engine (except those run by hand) to be furnished with two horses selected by the exhibitors respectively.

c. The engines to carry coal necessary for one hour's consumption, and also all tools and twenty-five feet of suction-hose, and all the men that are required to work the engine at the dock.

d. The engines and loads so made up are to be weighed.

e. The engines will be started together, and run over a course of at least one mile, returning to the dock, where they are to be worked for at least half

an hour from the time the first engine returns to the dock and commences playing; medium nozzles to be used by all the engines.

Trial No. 11 will be in all respects similar to No. 10, except a new fire may or may not be laid.

Trial No. 12 will be similar to No 11, but each engine will, if desired, take in a new supply of coal, and lay or not lay a new fire, as may be directed by the Judges.

Trial No. 13 will be similar to No. 12, except that each exhibitor will use any nozzle he may desire, both as to diameter and form.

The Judges will measure the nozzles so chosen, and the results of play will be duly considered in making up the account.

Rules to be observed at the Trial of Chemical Fire-Engines, to be held on the Grounds of the International Exhibition, commencing September 6.

Trial A, No. 1, will commence on the 6th of September, and all competing engines will take up positions at the dock, in front of the north central entrance of Machinery Hall, at 10 o'clock A.M.

a. Four charges of chemicals will be used by each engine, which will be weighed, and quantity of water ascertained for each charge.

b. To start at a given signal, with all valves closed, as if running on street.

c. Largest sized pro-rata nozzle to be used.

d. Pressure and duration of stream to be noted, which will include observations as to breaks or stoppages of the stream (if any) while changing plug from one tank to another.

Trial A, No. 2, will follow trial No. 1 immediately, and will continue as long as one tank of each engine will give a stream under a pressure of five pounds per square inch. The medium sized nozzle will be used.

Trial A, No. 3, will follow immediately, and be of the same nature as No. 2, except that the *smallest* pro ratâ nozzle will be used.

Trial B, No. 1, will be for length of stream and completeness of chemical combination, but may be omitted if the above facts have been satisfactorily ascertained during the preceding trials.

Trial B, No. 2, will be for extinguishing fire in a building to be erected by the exhibitors, at the north-east side of the grounds, near the wind-mills. Each exhibitor will build such size and kind of house as he may judge best, and also fill the same to an extent and with such kind of inflammable material as he may choose, but a careful account will be kept of all such material used, either in the construction or filling.

The building will be fired at a signal, and the engines will commence their efforts to extinguish the flames at another signal agreed upon. All facts developed by burning and work to extinguish the fire will be carefully noted.

Should a considerable portion of the building and material remain unconsumed after the first firing, it will be repeated one or more times under the same rules as at first.

Trial C, No. 1, will be for playing at the dock and running on the street, and will take place on the 8th of September, and will be carried on in connexion with the trial of steam fire-engines; and the chemical engines will be subject to the same general rules as to horses, and also being charged and equipped, ready for fire and street duty, &c., except that supplies will be carried for one half hour, and will play at the dock, exhausting but two tanks through pro-ratâ nozzles.

The pressure, duration of stream, time of departure and arrival, and, as far as possible, all other facts developed, will be duly noted.

Trials C, Nos. 2 and 3, will be of the same general nature in connexion with the steamers, and may be repeated if the Judges think it desirable to do so.

a. Pressure-gauges will be tested by the Judges previous to the trials.

b. In trials for pressure or length of stream, equal lengths of hose will be used by all the engines respectively.

TESTS OF TURBINE WATER-WHEELS.

Philadelphia, November 21, 1876.

JOHN S. ALBERT, Esq., Chief of Bureau of Machinery.

DEAR SIR,—I herewith inclose you the records of the tests of Turbine Water-Wheels made by me, at your request, in the Hydraulic Department of Machinery Hall, and, that the whole matter may be perfectly understood, will commence with a recapitulation of the apparatus employed for the purpose.

The water was furnished by a pair of powerful centrifugal pumps, exhibited by Messrs. W. L. Andrews & Co, of New York, and driven by oscillating engines, which raised from 1,800 to 1,900 cubic feet of water per minute to a tank placed at the end of the Hydraulic Annex, the overflow of which was 33 feet above the level of the water in the large tank in the centre of the building, from which it was pumped.

This water usually formed the "cataract," which was stopped partially or wholly while testing the turbines.

From this tank a wrought-iron tube or "penstock" 4 feet in diameter descended to the "flume," or case in which the wheels were set, and which was 8 feet in diameter by 6 feet in height, supported by a brick wall resting on a granite bedstone. From the wheels the water was conducted by an ample passage to a rack, or strainer, 30 feet from the wheel, and stretching across a brick tail-race 14 feet wide by 8 deep, at the lower end of which, 15 feet below the rack, was the measuring weir, 9 feet long, formed of a heavy cast-iron plate planed to a true edge $\frac{1}{8}$ of an inch thick, and bevelled from that on the further side at an angle of 45°. The upright ends of the weir were made of Georgia pine, cut and bevelled to the same dimensions, and were carefully adjusted by Mr. Samuel S. Webber, and verified by myself.

The hook gauge, loaned for the experiments by Mr. T. H. Risdon, was placed in a tight wooden box 6 feet up-stream from the weir, and the water was admitted to this box, for the purpose of measurement of height, by a few $\frac{3}{8}$ inch holes bored in the bottom of the box, 3 feet below the surface of the water; and an examination of the very thorough test of the Tait wheel shows the sensitiveness with which the weir measurement responded to the changes of load and variation in the number of revolutions of the wheel.

The apparatus for measuring the power consisted of a friction pulley fitted to the wheel shaft, 37.44 inches diameter and 18 inches face, which was clasped by a Prony-break, consisting of a pair of cast-iron shoes lined with wood, from one of which projected an oak arm 6 by 4 inches, through which a knife-edged eye-bolt was fastened at a distance from the centre of shaft of 10.50 feet, or the radius of a 66 feet circle. These portions of the apparatus, with the scale, pan, and hyhraulic regulator, 16 inches diameter, were also kindly loaned by Mr. Risdon.

To facilitate the handling of the weights, this lever was connected by an iron rod with the short arm of a bell-crank or scale beam 2 feet in height, while the longer arms, which were attached to the scale, pan, and regulator, were 4 feet each, thus giving a leverage of 132 to 1 for each pound placed in the scale. All the pivots or bearings of this scale-beam were of steel, knife-edged and bearing in hardened iron sockets.

The weights used were United States standard, and were kindly loaned by Messrs. Fairbanks & Co. The pulley, weighing 1,000 pounds, rested on the shaft and step of the wheel, corresponding in some measure to the usual "crown gear;" but the brake, which weighed 1,600 pounds, was suspended by a swivel from a beam directly over the centre of the wheels, so as to allow perfect freedom of motion in any direction. An examination of the records will also show the sensitiveness and accuracy of this part of the apparatus, every distance and dimension of which I carefully measured and adjusted personally before commencing the tests.

The head of water acting on the wheels was ascertained by a gauge-rod, having a hook at the lower end, which was carefully kept at the level of the tail-water in a box sunk in the floor and connected with the tail-race by a perforated pipe; while a pipe led from the case to the level of the head water, where a glass tube enabled the observer to read at once the acting head, by the graduations on the upper end of the gauge rod.

Experiments not strictly belonging to the wheel tests were made, showing that the same wheel, with the same load, at different times repeated the

number of revolutions very accurately, and proved the correctness of the apparatus. The revolutions of the wheel were ascertained by a worm-gear clock, which was thrown in and out of connexion with the shaft of the wheel, at signals given by a bell, which was struck at intervals of 1 or 2 minutes, according to the length of test desired.

The friction pulley was accurately balanced before commencing the tests, and when the wheels themselves were truly set, ran with perfect steadiness and regularity.

In conducting these tests, I have been assisted by the following gentlemen, our watches being all set at the same time before commencing the tests, and simultaneous observations being taken during their entire duration. These observations being noted down as taken, a comparison of the different note-books gave a record of all the points in the test at every half-minute of its duration.

Mr. Percy Sanguinetti read the hook gauge, giving the height of water on the weir; Mr. P. W. Voorhees read the gauge giving the head of water acting on the wheel; Mr. Samuel S. Webber managed the counting clock and read the revolutions of the wheel, and also saw that the lubrication was perfect; while Mr. John Cotter, Superiniendent of the Hydraulic Annex, kept the records of the weight and revolutions, and assisted me generally in various ways. I personally kept an eye on all points, and gave the bell-signals by which the observations were taken; and to all of the above-named gentlemen who assisted me I desire to return my thanks for their fidelity to their duties, and their active co-operation, as well as to Mr. Johnson, who handled the wrench by which the friction of the break was regulated, and to the engineers in charge of the Andrews pumps for their uniform patience and courtesy under, at times, very trying circumstances; and also to all the employés who took charge of the less prominent but not less important parts of the operations.

Each exhibitor was allowed free access and liberty of observations during the tests of his own wheel; and, whatever may be the accuracy of the net results obtained, the comparative ones may be depended on, as the tests were all made under similar circumstances, and the different points watched and the notes taken throughout by the same observers, none of them having any interest whatever in the result, or any opportunity at the time of knowing what the observations were at other stations than their own.

It is worthy of notice that the best results have been attained by wheels taken just as they came from the shop, without any especial finish or preparation, and the thoroughly exhaustive test of the Tait wheel is worth studying, as showing the accurate working of the apparatus.

The Geyelin wheel, entered by R. D. Wood & Co., was so tightly fitted in the shop that I do not think we got a fair record of its power; and the Cope wheel used so much water that we could not carry the test out in full, but the percentage was gaining regularly up to the last trial, when we exhausted the supply of water, having reached over 1,860 cubic feet, or about 14,000 gallons, per minute.

The Hunt wheel also taxed the supply of water to the utmost. The Tyler wheel was too loose in the upper bearing on the second trial, and the third wheel, from the York Co., was only tested to prove or disprove what was believed to be an unsound principle, viz., that of shallow buckets and central discharge; and the result is confirmed by those obtained from some of the other wheels.

The leakage of the flume was large during the first six trials, but by caulking and tamping with lead was very much reduced at the test of the Tyler wheel, after which test the allowance was uniform of 14,352 cubic feet per minute waste to each wheel. In the first six tests it was taken as noted in the tables, and the amount is in all cases deducted from the water consumed per minute.

Believing that this report will afford all necessary explanation of the Tables, and thanking you and the other officers of the Machinery Department for your cordial assistance and co-operation, I remain

Very truly yours,

SAMUEL WEBBER,

Superintending Engineer Centennial Turbine Tests.

GENERAL REPORT

ON

GROUP XXI.

MACHINE TOOLS FOR METAL, WOOD, AND STONE.

JUDGES.

American.	*Foreign.*
George H. Bleloch, Springfield, Mass.	John Anderson, LL.D., C.E. (President), Great Britain.
W. F. Durfee, New York, N.Y.	François Perrier, France.
John A. Anderson, Manhattan, Kansas.	C. A. Angstrom, Sweden.
	Auguste Gobert, fils, Belgium.
	Felix Reifer, Austria.

GENERAL REPORT.

MACHINE-TOOLS FOR METAL, WOOD, AND STONE.

The International Exhibition held on the grounds at Fairmount in 1876 will stand out prominently as the greatest ever held for the display of the various descriptions of articles that may be classed under the word useful, and still more was it remarkable for the unequalled collection of products that may be said to combine the useful with the beautiful. In no former exhibition of the products of industry had the pre-eminently useful class of machines which fall under the nomenclature of machine-tools, and of which Group XXI. takes cognizance, been so grandly represented; and the grandeur of that display is not effected by the mere repetition of well-known machine constructions, but rather by all that constitutes novelty, originality, and progress in regard to the rapid production of the goods and the reduction of cost, all tending in the direction of lessening the labour of the human race in the supply of its own wants.

The enormous stride which has been made in machine-tools since the ever-memorable Exhibition held in London in 1851 is a perfect marvel. The change, however, has gone on by a series of such imperceptible increments, that it is only the observing and experienced student who can appreciate the full measure of the advance that has been made. More especially is this the case in regard to the several classes of machine-tools for wood for which the United States have become so distinguished. In that year (1851) the comparatively small display of machinery for wood-working that was sent from America, and which was exhibited in London, took the rest of the world by surprise; but even that display, if now placed beside the gigantic and unrivalled collection that was here displayed at the Centennial, would be considered as scarcely worthy of award or even of notice. Still it contained the living germ, which has, under the fostering ingenuity of many inventive minds, grown up to the colossal dimensions of 1876; and to enable the general public to know the vast advance that has been made it would require the two to be placed side by side.

In regard to circular saw-mills for cutting up the round logs of the lumber-trade, the United States made a very grand and unequalled display. This class of machinery has been the subject of much study, and has at length arrived at a very high standard of excellence. It is distinguished for efficiency and rapidity of execution, and is worthy of the study of all energetic nations.

Since 1873 the progress made in wood-working machinery is most conspicuous. Ever since 1851 the old flimsy forms have been gradually giving way to a more substantial manner of construction, and the tawdry finery of paint in various colours has given place to a more severe and uniform style. At Vienna most of the American exhibits appeared in a greatly improved character; and at the Centennial Exhibition we had nearly all the larger class of firms with entirely new designs of the highest excellence, and with such originality shown in every direction and pervading all classes of machine-tools, and to such an extent, as to warrant us in saying that never before had so much originality been brought together in one place as at Fairmount Park in 1876. In America alone there were upwards of eighty large exhibitors of wood-working machinery, many of the single firms showing an immense number of different classes of machinery, most of them characterised by great refinement, accuracy, fitness for their intended purpose, balanced spindles, and minute attention given to truth in the details. So marked was the change, that in wood-working machinery the United States may be considered as taking a new departure from the Centennial year.

Similar remarks apply to the metal-working tools of America, but their points of excellence are of a still higher order of refinement and mathematical

precision, and they stand out in every respect that contributes to perfection in work, both as regards mathematical accuracy and the reduction of cost in the product.

Notwithstanding the fact that a number of different countries contributed their good-will offering to the Centennial, it must yet be distinctly understood that, so far as machine-tools are concerned, the enormous display from the United States so far exceeded that from all the rest of the world put together that, in this section, the competition may be said to have been American rather than International.

Russia.

The machine-tools displayed by Russia were limited in number. Still, Russia made a better display at Philadelphia than she did at London, Paris, or Vienna; more especially in the beautiful collections of the polytechnic schools of Moscow and St. Petersburg, both showing remarkable progress in refinement and precision in all the elements of applied mechanics, a branch of the utmost importance to that country, where such knowledge is not inbred in the population, as is the case in some other countries. A private firm from Russia also displayed some fine specimens of machine-tools for metal, of excellent construction.

Brazil.

The Empire of Brazil presented some well-constructed tools, or machines, in connection with mint-operations. These specimens of good workmanship were excellent in their style and finish.

Sweden.

The machine-tools sent from Sweden were worthy of all commendation; everything sent was good of its class, and all were notably free from prevalent mechanical errors. At each recurring Exhibition this country invariably shows progress, and on the present occasion its sawing-machinery and that for cartridge manufacture were deserving of careful examination.

Belgium.

Belgium did not show much in this section, but everything exhibited by that kingdom was very good. A machine for making nuts, more especially, was very superior; and although from some arbitrary reason it was not classed with machine-tools, yet we venture to say that it shows a remarkable degree of progress since the Exhibition of Vienna 1873.

France.

Considering the distance from Philadelphia, France did well at the Centennial Exhibition. In wood-machinery more especially she greatly excelled. France alone had the credit of planing with the helical-cutter; at Vienna it was the object of much admiration, and was here again submitted, and is deserving of commendation. An ingenious method of shaping the staves of casks was characterised by much refinement, affording mathematical accuracy combined with rapidity of execution, and is well worthy of study by the tool-makers of other nations.

Germany.

Although Germany showed little in the section of machine-tools, still it presented one machine of great merit. It was for cutting the teeth of small bevel-wheels by a circular cutter, to which was added a second motion that gave a sort of wabbling movement to the cutter, thereby shaping out the required mathematical lines, or was capable of being made to do so. This was one of the gems of the Exhibition; although in its construction at the present

time it is a rough diamond, still, it contains the germ of a useful machine Another tool for grinding flat surfaces is ingenious in some of its arrangements, but is not quite so perfect in its details.

Canada.

Canada made a great and noble effort. Some of its machine-tools had considerable merit and contained many points of originality. They were all of good, sound workmanship, and, taken altogether, were good, serviceable tools, and showed encouraging progress. It may be remarked, however, that the true tool spirit is not yet so fully developed as it undoubtedly will be. At the present time, whenever Canada holds on to established lines of construction it does well; but when it ventures to leave the beaten track, it is apt to stumble and to introduce devices that are ingenious but imperfect in principle. Its beautiful radial drill is marred by an apparently trifling detail, yet this trifle reduces the value of the machine, at least where accuracy and precision are essential. As a whole, Canada showed much progress at Philadelphia.

Great Britain.

With the exception of the United States of America, Great Britain made the largest display of machinery at the Centennial Exhibition. In machine-tools, however, that country was scarcely represented. A remarkable exception was the steam-hammer sent from Manchester. The birth-place of the steam-hammer contributed a grand display, which was worthy of the most careful examination by earnest students who desire to learn a lesson in good, sound construction. Another ingenious machine, from Lancashire, was for engraving calico printing rollers, or rather for stamping by impact, or by milling, or by both combined. Leeds put forward several good machine-tools for various purposes; but when all are reckoned up they were as nil when compared with one exhibit from Philadelphia which stood alongside, and which threw all other, and, indeed, all former exhibits by single firms, entirely into the shade. England likewise supplied an excellent and most valuable machine for dressing stones, which was well worthy of careful attention. We regret that Great Britain, which stands so high in this class of machinery, was not better represented. The exhibit of that country was conspicuous by the absence of all the well-known names with which the world has been familiar.

GENERAL REPORT

ON

GROUP XXV.

INSTRUMENTS OF PRECISION, RESEARCH, EXPERIMENT, AND ILLUSTRATION, INCLUDING TELEGRAPHY AND MUSIC.

JUDGES.

American.	*Foreign.*
Joseph Henry, LL.D., Secretary of Smithsonian Institution, Washington, D.C.	Sir Wm. Thomson, LL.D., D.C.L., F.R.S., Great Britain.
F. A. P. Barnard, S.T.D., LL.D., Columbia College, N.Y.	Jul. Schiedmayer, Germany.
J. E. Hilgard, Washington, D.C.	E. Levasseur, France.
J. C. Watson, Ann Arbor, Mich.	P. F. Kupka, Austria.
H. K. Oliver, Salem, Mass.	Edw. Favre Perret, Switzerland.
Geo. F. Bristow, New York.	

GENERAL REPORT.

INSTRUMENTS OF PRECISION, RESEARCH, EXPERIMENT, AND ILLUSTRATION, INCLUDING TELEGRAPHY AND MUSIC.

By J. E. Hilgard.

The members of the Board of Judges assigned to Group XXV. met for organization on the 25th of May, there being present Messrs. Henry, Barnard, Hilgard, Watson, Oliver, and Bristow, of the American Judges, and M. Levasseur, of France. Professor Henry was called to the chair; and Professor J. C. Watson was elected permanent Secretary. Sir William Thomson, of Great Britain, was elected President of the group, Professor Henry consenting to preside until his arrival.

The following assigment of subjects was made to the several Judges, subject to any modification consequent upon the arrival of absent members from abroad:

Class 320.—Astronomical and Surveying Instruments: Messrs. Watson, Hilgard, and Kupka, of Austria. Meteorological Instruments and Apparatus: Messrs. Levasseur and Henry.

Class 321.—Indicating and Registering Apparatus other than Meteorological: Messrs. Barnard, Hilgard, and Kupka.

Class 322.—Weights and Measures, Weighing and Meteorological Apparatus: Messrs. Hilgard, Levasseur, and Kupka.

Class 323.—Chronometers, Clocks, Watches, &c.: Messrs. Watson and Favre-Perret, of Switzerland.

Class 324.—Optical and Thermotic Instruments and Apparatus: Messrs. Henry and Barnard. Telescopes: Mr. Watson.

Class 325.—Electrical and Magnetic Apparatus: Messrs. Thomson, Henry, and Barnard.

Class 326.—Telegraphic Instruments and Methods: Messrs. Thomson and Henry.

Class 327.—Musical Instruments: Messrs. Oliver, Schiedmeyer, of Germany, Bristow, and Kupka. Acoustic Apparatus: Messrs. Henry and Barnard.

Sir William Thomson and Mr. Schiedmeyer joined the group on June 5, and Mr. Kupka on the 6th. Mr. Charles E. Emery, one of the Judges in Group XX., was assigned to assist in Group XXV., in the department of Electricity. In the absence of Mr. Favre-Perret, who only arrived on the 20th June, he was represented by Mr. Gribi, one of the Commissioners from Switzerland, as an expert in the department of Horology. Professor Vogel, of Berlin, was appointed as an expert on the part of Germany in Classes 320, 322, 324, and 326; and Professor Reuleaux of Germany, in Classes 321 and 322. Dr. Fleischl, of Austria, one of the foreign Judges, was, at the request of Group XXV., assigned to act as a Judge of Microscopes in the group. Sir William Thomson being obliged to leave on June 28, Mr. Hilgard was elected Chairman, and acted as such to the close of the work.

In regard to the general character of the exhibit, it may be said that the most advanced state of science and art was represented in all departments of the group except in that of astronomical and geodesic instruments of the larger class. This arose from the nature of the case, as such instruments are only made to order, and cannot usually be spared from their uses.

CLASS 320.—Astronomical, Surveying, and Levelling Instruments—Meteorological Instruments and Apparatus.

This class comprised several distinct categories of scientific instruments; those of astronomy, geodesy, and surveying; instruments for mathematical drawing, hydrographic apparatus, meteorological instruments of all kinds; and in addition to these, chemical and physical apparatus.

The larger class of astronomical instruments was not represented at all, since they are difficult of transport, and are only constructed to order. Of the portable astronomical instruments, the principal exhibit was in the Government collection of the United States, which comprised a complete exhibit of the instruments and apparatus used in the transit of Venus expedition sent out by the United States.

The firm of Faut & Co., of Washington, however, exhibited an equatorial of excellent construction. Its object-glass, of 6½ inches aperture and 8 feet focal length, was made by A. Clark and Sons, of Cambridgeport. The same firm also exhibited a geodesic theodolite of approved construction, which was the only instrument of its class in the Exhibition, besides those in the collection of the United States Coast Survey and United States Engineers.

A portable transit-instrument, made by Edward Kübel, of Washington, for the United States Coast Survey, deserves special mention here, as it could not receive an award, from the circumstance of its being in the Government exhibit.

In geodesy proper, no other nations could be compared with the United States, because none had sent the instruments and documents relative to the geodesic operations carried on by them; while the United States, on their part, had made a complete and very remarkable exhibition by collecting in the Government Buildings the maps, instruments, and reports of the Coast Survey and the War Department. Among the instruments which particularly attracted the attention of geodesists, were the apparatus for measuring base-lines, that for comparing the measuring-bars with standards, and the apparatus for determining personal equation in observing transits for time; also the combined instrument for observation of time and latitude, and the chronographic apparatus.

The United States possess an immense territory, almost as large as Europe, which requires to be surveyed and divided into properties, and where a rapidly-increasing population is occupying new lands and building new houses and towns. It is not surprising, therefore, that the fabrication of surveying instruments should be a flourishing branch of industry. There were more than a dozen exhibitors from the United States in this branch, among whom several are distinguished by ingenious detail of construction and perfection of workmanship. The exhibit of Switzerland in the same line of instruments is also worthy of special mention, as well as a levelling instrument of novel design, for work of precision, from Portugal.

In mathematical and drawing instruments, Aarau, in Switzerland, continues to be one of the important centres of manufactures in Europe. Nuremberg, in Germany, produces especially ordinary articles at low prices. The United States are distinguished in this line by the variety of their rulers, straight and curved, in hard rubber. In this category may be mentioned dividing-machines, of which there were several, among which the most remarkable was that of W. A. Rogers, of Cambridge, Massachusetts. Special mention, also, should be made of several forms of motion, exact right-line movement produced by circular motion, the discovery of Professor Chebicheff, of Russia, by which the solution of a heretofore unsolved mathematical problem is attained.

The instruments of hydrography consisted of marine compasses, logs, and sounding apparatus. The compasses of Ritchie, of Boston, were much approved by the Judges, as well as the apparatus of B. F. Greene, exhibited in the United States Navy Department, for correcting compasses on iron ships. In logs, several improvements were noticed and rewarded. The apparatus for deep-sea soundings by means of steel wire, with improvements by an American naval officer upon the original plan of Sir William Thomson, deserves special mention, as well as the self-registering deep-sea thermometers of Negretti and Zambra, of London.

Sweden, whose savants have applied themselves with so much success to the exploration of the ocean, had a very complete exhibit of instruments for exploration of the deep-sea fauna and flora, such as dredges, drag-nets, water-bottles, &c.

The instruments of meteorology were very numerous. France, England, and the United States had some fine Fortin barometers, and a rich collection of aneroids, without, however, showing any important novelty. The only barometer constructed on a new principle is that of Mendelieff, of Russia,

designed for measuring small differences of elevation with great accuracy. The most remarkable exhibits were those of instruments for meteorological stations, among which those of the Weather-Signal Bureau of the United States Government were the most extensive, comprising, besides instruments for ordinary observation, a complete series of self-registering meteorological instruments.

Two other countries had apparatus for automatic registration equally worthy of consideration. That of Sweden registers and prints, in figures, every quarter-hour, the barometer, temperature, direction, and force of the wind. That of Holland inscribes the observations on a copper-plate, and also registers electrically the indications at different stations at some central point.

Several countries exhibited collections of physical and chemical instruments for purposes of instruction and for laboratories of science. England, France, and the United States were particularly distinguished in this branch, although the exhibit was in no case as large and important as the branch of industry merited, supplying as it does so great a number of schools and colleges. Among the exhibits mentioned were several special ones, remarkable for the merit of scientific invention not less than quality of construction.

Several nations exhibited collections of instruments of this kind, which, judged in an absolute manner, would not have appeared to deserve an award either for novelty or for finish. The group has, nevertheless, given some awards in such cases, because it desired to encourage those who apply themselves to supplying, at low prices, the smaller schools with apparatus adapted for the demonstration of the great laws of nature. The Province of Ontario, Canada, would have had an award of this kind if it had not declined competition.

Class 312.—Indicating and Registering Apparatus other than Meteorological.—Mechanical Calculation.

The most important exhibits of this class were the two calculating-machines of Mr. George B. Grant, of Cambridge, Massachusetts, the larger one of which is arranged to combine aud print functions involving one hundred elements. The combination of the several parts is extremely simple ; the number of elements can be indefinitely increased, and the machine acts with the greatest certainty. The smaller machine, or arithmometer, is an adding-machine, which successfully rivals the well-known one of Colmar. The adding-machine of Petersson, of Norway, also deserves special mention here.

Next in importance in this class are water-meters. The growing demand for an instrument of this class which should be cheap enough to be applied to every dwelling, and, with a moderate accuracy, should not be liable to get out of order, has greatly stimulated the invention of water-meters. A great variety of such instruments was presented, the greater number from the United States,—France, Holland, and England each contributing one. It was determined to put these instruments to the test of actual performance under pressure varying from five to eighty pounds. The experiments were arranged in the hydraulic annex of the Machinery Hall, with the kind co-operation of Mr. John Cotter, engineer in charge. Mr. W. F. Blake volunteered the use of his steam-pump, by means of which it was practicable to keep up a uniform pressure of any desired degree, indicated by the pressure-gauge. The Dutch meter proved to be out of order and could not be repaired. The English meter and one or two others gave way under the pressure of eighty pounds. All the rest stood the test to the satisfaction of the Judges, and have received awards.

The ingenuity of device in many of these instruments elicited the admiration of the Judges ; but it would be invidious to particularise any one here without entering fully into the subject. There are in general two classes of water-meters, one in which the indications are derived from the actual measuring of the volume of water delivered, while in the other class the indications are in some way dependent on the flow of the water. The former, which may be called displacement-meters, are obviously the more accurate form, while the latter are generally of simpler construction, and appear to give sufficiently true results under varying pressures,—the principal object in view, in the

general employment of water-meters in a city, being rather to check excessive waste than to obtain a very accurate measure of the amount used. It is probable that instruments of the latter class will be found best adapted for general introduction into private houses, and the former for large manufactories and hotels.

Ships' logs have been mentioned, as well as hydrographic apparatus, in the previous class.

In gas-meters no special novelty was exhibited.

Class 322.—Weights, Measures, Weighing and Meteorological Apparatus.

In measures of length and graduated scales on wood and metal, and graduated tapes of linen or steel, and in tools for gauging casks, the United States alone were represented. Most of the exhibits showed a high order of perfection, being made by machinery expressly devised for the purpose.

In hydrometers and alcohol-meters, the United States Government and that of the Netherlands made important exhibits of instruments used in their several revenue departments. The Judges saw something to commend in a new apparatus for testing the quality of milk, by Tagliabue, of New York, which attempts to arrive at the quality of milk by coagulating and measuring its solid contents. But while this method may be more certain than the areometer, it is perhaps too laborious for ordinary use, and a satisfactory lactometer still remains a desideratum.

Balances and scales occupied a large place in this class. In balances of precision, France was represented by Deleuil, and the United States by Becker & Sons. The instruments of both these houses are of the highest order of excellence. As the circumstances of the Exhibition buildings did not permit their test on the premises, accurate weighings were made with them at the United States Mint, and at the Coast Survey office, in Washington. The accuracy of the Becker balance was shown by numerous tests to be about $\frac{2}{100}$ths of a milligrame when loaded with 400 grammes.

Among balances of precision, the short-armed laboratory balance of T. Sartorius, of Göttingen, Germany, is noteworthy. Some experimenters suppose this to be preferable to the long-armed balance heretofore constructed. The more rapid vibrations of such a balance doubtless afford a certain advantage in rapidity of work; but where extreme precision is required, as in the adjustment of standards, it cannot compete with the balance of Becker or Deleuil.

The exhibit of platform scales for purposes of commerce was very large, France and the United States being the principal competitors. In this branch of industry the United States lead the world in the adaptation of their scales to various uses and in excellence of construction.

No actual tests of performance were made by the Judges of the various platform scales, inasmuch as the important qualities of permanence of adjustment and of endurance of sensibility could not be tested by any trials that could be instituted on the occasion, while any balance could be easily adjusted as might be required for the occasion.

In this department the house of Fairbanks & Co. are entitled to special mention as having in a great measure originated and largely developed this large branch of industry in the United States, and having, by their various adaptations, greatly facilitated the operations of commerce. In the same branch of manufacture France was very creditably represented by L. Paupier.

A comparatively modern form among weighing-machines is the railway platform scale, of which the conditions are, that it shall always be ready for action and admit of loads as great as forty tons being rolled upon it without injury to its suspension. The construction of these machines is most developed in the United States, and the plan of Riehlé Brothers, of Philadelphia, has appeared to the Judges to offer the greatest guarantee of accuracy and durability. Owing to the great size of these machines, their manufacture in other countries was represented only by models or designs.

Class 323.—Chronometric Apparatus.

The Committee on timekeepers made a careful and detailed examination of chronometers, watches, and clocks. Where the claim was for quality of

workmanship, they examined all the parts, and where the excellence of the timekeeping properties was involved, actual trials were made. For the detailed results of these trials, as well as a general review of the subject of the state of horology as developed by the Exhibition, the appended report by Professor Watson may be consulted.

Optical Instruments.

By F. A. P. Barnard, S.T.D., LL.D.

The display of optical apparatus, though not large, was interesting, but contained comparatively little of novelty. Of instruments designed for investigation and research, the number of exhibitors hardly exceeded half a dozen. Among these the most conspicuous place must be assigned of right to Mr. J. Duboscq, of Paris, whose splendid apparatus for spectroscopic observation, and for researches in physical optics, constituted not only the best, but the only important collection present belonging to these departments of optical science. Of optical glass the displays were very fine, those of Messrs. Chance Brothers and Co., of Birmingham, England, and of Feil, of Paris, leading, as might have been expected from their long-established reputation, all the rest. The disks exhibited by the first-mentioned of these firms were largest in diameter; but those of Mr. Feil, of 50 centimetres, were superior in beauty, with scarcely even a microscopic blemish. The specimens of heavy glass exhibited by Mr. Feil were also very remarkable. The specific gravities of these varied between 2·52 and 5·25; and the refracting powers between 1·51 and 1·79. A very interesting collection of artificial gems was also presented by the same exhibitor, the results of a series of investigations in which he has been engaged in recent years, and in which he has succeeded in imitating, to a high degree of perfection, the hardness, the colour, the transparency, and the other physical properties of the natural crystals.

The department of optical science most fully represented in the Exhibition was that of microscopy. Even in this, however, we had to regret the absence of some of the most distinguished constructors, among whom may be mentioned Messrs. Spencer & Tolles, of our own country, Messrs. Powell & Leland, of London, and Mr. Hartnack, of Paris. In some of the microscope-stands exhibited, certain minor features of novelty presented themselves, which deserve notice as being real contributions to the facility of manipulation. Such are the plan of fine-movement adjustment embodied in the stand of the Bausch & Lomb Optical Co., of New York, and also the immersion condenser adapted to the same stand. In the new form of stand constructed by Joseph Zentmayer, of Philadelphia, are introduced a number of such minor improvements, which render that stand probably the most convenient in use of any now made, although it is necessarily somewhat expensive.

In the examination of microscope objectives, the Judges had the assistance of some practised experts not belonging to the Board. So close is the competition at the present time between different constructors, and so difficult are the tests of comparative excellence between objectives of the higher powers, that great care was felt to be necessary in forming and pronouncing opinions. In making the practical tests, the instruments were removed from the Main Building, where they were exhibited, to the gallery of the Judges' Hall, which, from its favourable exposure, furnished a satisfactory illumination. During the trials, the exhibitors themselves, as well as the assisting experts, were present; and to their courtesy in making every desired arrangement to facilitate the scrutiny the Judges feel themselves greatly indebted. In most instances, after a sufficiently protracted examination of test-objects by the different observers, and a comparison of opinions, judgments were formed without resorting to any corroborative test; but in the case of one or two of the higher powers, photographic impressions of difficult objects were taken by means of the objectives, and the images compared. In this part of the investigation the Judges have to acknowledge the kind assistance courteously lent them by Colonel J. J. Woodward, M.D., of the Army Medical Museum at Washington, in preparing the desired photographs in his physical studio, which is probably more admirably adapted to operations of this kind than any other in the world. It was satisfactory to find that the results of the photographic tests were confirmatory of the judgments which had been previously formed by direct observation.

Among the objectives exhibited were examples of all the varieties of construction employed by the most eminent makers of the present time. The high powers of Dallmeyer are formed of three achromatic combinations, and are designed to work dry; but by the removal of the outer combination and the substitution of a simple front, they are convertible into immersion lenses. The constructor, indeed, appears to entertain very little respect for the immersion principle, and intimates that he has made provision for this transformation only in compliance with a popular fancy; yet his objectives, whether tested by direct observation or by photographic impressions, perform certainly more satisfactorily when used as immersion glasses with the simple front than when working dry.

The high powers of Negretti & Zambra embrace, besides the three achromatic combinations of Dallmeyer, an additional simple front. Some of those of Beck and of Wales consist of only two achromatic combinations with a simple front; while Ross has adopted the construction originated by Mr. Wenham five or six years ago, in which a single achromatic combination is placed between two simple lenses.

Apparently a favourable opportunity was presented by this Exhibition for fairly testing the comparative merits of these several modes of construction; but in point of fact no conclusion which might be drawn from the relative performance of these particular specimens could be justifiably extended to the principles on which they are constructed. Different opticians, indeed, while working on the same plan, do not necessarily grind their curves according to the same formulæ; and even the same artisan employs different formulæ for the same powers at different times. Greater variations, moreover, may sometimes be found in the performance of objectives constructed upon the same plan, and designed to be identical, than will be detected in comparisons between others in which the principles of construction are entirely different. If we say, therefore, that no better performance was obtained from any of the objectives on exhibition than was given by some of those which consisted of two achromatic combinations and a simple front, it is with no intention of expressing a judgment more favourable to this than to other modes of construction, or of questioning that equal excellence may be obtainable upon the more complex plans of Negretti & Zambra and of Dallmeyer, or upon the simpler plan of Ross. It is to be hoped, indeed, that this simpler plan may yet be found the most advantageous, since thus a reduction in the cost of high-power objectives might reasonably be expected. As yet, however, lenses of this construction have not been offered on terms materially more favourable than those of corresponding power, of which the greater complication and the larger number of elements exact certainly a considerably greater amount of skill and labour to produce them.

Of objects prepared and mounted for microscopic observation a few collections only were exhibited, but these were remarkably excellent. Among them may properly first be mentioned a series of vegetable tissues prepared by Dr. George D. Beatty, of Baltimore, and stained in double colours by a process which originated with himself. Larger collections were shown by Wm. H. Walmsley, of Philadelphia, and Edmund Wheeler, of London, in which the same process had been employed, and which for neatness and delicacy deserve very high commendation.

Lenses, prisms, and mirrors were present in great numbers, and in every variety of form. Among the exhibitors of photographic lenses were embraced the widely-known constructors Ross, Dallmeyer, Voightlander, Derogy, and Busch (the latter represented now by the Rathenow Optical Company). These lenses were only tested by the examination of their certified work. Their reputation, moreover, had long preceded their appearance here. Generally, each exhibitor presented lenses constructed upon different formulæ for different kinds of work. The portrait lenses of Dallmeyer were provided with a useful adjustment for varying the depth of focus, an effect which is accomplished by increasing or diminishing the distance separating the two lenses of the posterior combination.

Of cameras, camera-stands, and other descriptions of apparatus designed to facilitate the mechanical operations of photography, there were many forms possessing merit; but among all these the palm must be awarded to the Scovill Manufacturing Company, of New York, for elegance, for excellence of workmanship, and for the variety and ingenuity of the expedients employed to promote the convenience of the operator.

A great variety of projection lanterns were exhibited, many of them double, for dissolving views, and one of them triple. These instruments are all similar to one another in their leading features, though differing in minor details. Some of those exhibited embraced the important improvement originally introduced by Prof. Henry Morton, now president of the Stevens Technological Institute, Hoboken, New Jersey, by which the horizontal lantern is convertible into a vertical lantern, for the projection of objects immersed in liquids. The projection lantern has become an almost indispensable part of the apparatus of instruction in nearly every department of human knowledge, and the improvements made in it in recent years, as illustrated in the varieties exhibited, are very great.

Of spectacles, eye-glasses, opera-glasses, and hand-telescopes, monocular and binocular, the exhibitors were very numerous, and many of the articles exhibited were of great merit. In general the constructors of these instruments are not the manufacturers of the material of which their lenses are made. A noticeable exception occurs, however, in the case of Messrs. Willson & Co., of Reading, Pennsylvania, who prepare the discs for their spectacle-lenses by a process of their own, in which each disc is separately moulded under pressure. By this means are secured perfect freedom from striæ and uniformity of density. Among the other exhibitors whose work appeared to be especially meritorious may be named the Bausch & Lomb Opitical Co., of New York, the Spencer Optical Manufacturing Co., of New York, and the Spectacle-Makers' Society, of Paris, France.

Acoustic Apparatus.

In the department of acoustics, as represented in the Exhibition, the field was occupied almost wholly by a single exhibitor, Dr. Rudolph Koenig, of Paris. As a constructor, indeed, Dr. Koenig may be said to have monopolised this field before the world almost as exclusively as in the Exhibition, for it is to his skill that the most eminent investigators have been accustomed continually to resort for the means of realising their many ingenious conceptions.

The collection of acoustic apparatus exhibited by Dr. Koenig was remarkable, first, for completeness, as embracing every variety of instrumental appliance required for the study of sonorous vibrations, or for the demonstration of the phenomena of sound; and secondly, for the scale of unprecedented magnitude on which the principal instruments were constructed. It is gratifying to know that the most important of these, at present entirely unique of their kind, have been secured for one of our prominent educational institutions, where they will be likely to be made serviceable to the progress of American science.

Electrical Apparatus.

By Joseph Henry, LL.D.

A special feature of the Exhibition was the varied applications of electricity to different purposes in the arts, and especially to social economy. We mention first the appliances used for developing electricity.

Magneto-Electric Machines.

These are instruments for developing electricity by means of magnetic induction. If a long insulated wire be wound around a cylinder of soft iron and the projecting ends of this cylinder be brought in contact with the poles of a horse-shoe magnet, a current of electricity will be developed, for an instant, in the wire, at the moment of completing the contact. While the cylinder remains in contact with the magnet no current is observed in the wire, but when the former is suddenly pulled off an instantaneous current is evolved in the wire, which has a direction opposite to that of the current induced at the moment of contact. Magneto-electric machines are therefore constructed on the principle of rendering magnetic a core of soft iron, surrounded with insulated wire, and of rapidly reversing its polarity. The first machine for this purpose, which produced sparks, the decomposition of liquids, deflagration of metals, &c., was invented, in 1833, by Joseph Saxton, an American, residing at the time in London. A slight modification of Mr. Saxton's invention was adopted by Clark, an instrument-maker in London, who claimed the invention

of the machine as his own, and succeeded in having his name attached to it in works on physics in the French and German languages. Since the invention of Saxton, various improvements have been made on the machine by different persons. Siemens invented an improved rotary armature, in which the insulated wire is wound in the direction of the length of the soft-iron core; and which, being made to revolve before the poles of a number of horse-shoe magnets arranged in a row, gave a great increase in the quantity of the induced current.

The greatest improvement, however, was made by an application of the fact that the current induced by a feeble magnet was capable of inducing, by a rapid revolution of the armature, a much higher degree of magnetism than that of the first inducing magnet itself. This paradoxical result is readily understood when we reflect that every revolution of the armature produces two opposite currents of electricity, which may be reduced to one by a commutator, and that therefore the number of electrical impulses evolved in a given time depends upon the number of revolutions. In the case of a feeble inducing magnet these impulses are also feeble, but by increasing their number the magnetic development in the soft iron core to which they are applied becomes greater than that of the original magnet. The first application of this principle was by Wilde. The machine was, however, improved by Ladd and Wheatstone.

The electro-magnetic machines exhibited at the Centennial Exhibition were those of Gramme, of France, and Farmer, of the United States. The Gramme machine differs from all others of the class in the form of the soft iron core in which the magnetic induction takes place. This core, instead of being a cylinder of soft iron, is a ring formed of a coil of a long piece of iron wire, around which at intervals, transverse to the circumference, are wound a number of coils of insulated copper wire, the ends of which are soldered together into two projecting poles. This ring is made to revolve with great rapidity between the poles of a horse-shoe magnet, in the same plane with them. By this arrangement every point in the ring is magnetised in succession, and a constant current of electricity is produced, of great energy, in one direction. The inducing magnetism may be either a permanent magnet or an electro-magnetic magnet. In the latter case, the machine embodies the principle of increasing the intensity of the inducing magnetism by transmitting around the electro-magnet the induced current. If a machine of this kind with its circuit complete has no residual magnetism in its iron it might be turned at any speed, however rapid, without exciting any electrical current, and, unless the speed exceeds a certain limit, the electrical quiescence is a condition of stable equilibrium, but if the speed exceeds this limit the condition becomes unstable, and an infinitesimal quantity of magnetism would be sufficient to induce a current which, in turn, would be continually increased to an extent only limited by the rapidity of movement. The electro-magnetic machine has important practical applications in the development of electricity for electro-plating, electrotyping, for light-house uses, and other purposes of intense illumination. The magneto-electrical machine, however, does not transmit and apply power without great loss of original energy. If, for example, it be actuated by combustion derived from coal, only a very small portion of the energy applied will be reproduced, but this reproduction will be in a form of vastly increased intensity. The machine collects energy, as it were, diffused over a large space, as in the furnace, and concentrates it in a small volume; it receives it at a low temperature, and evolves it at an enormous degree of heat; it receives comparatively dark heat, and transforms it into radiant light of great intensity. Its province, therefore, is the transmutation of energy.

Electric Batteries.

Among the apparatus for producing electricity, galvanic batteries of various forms were exhibited. The most important among these, in regard to novelty and useful effect, was one exhibited by Mr. Byrne, of Brooklyn, New York. This is of the ordinary construction of plates of amalgamated zinc and carbon, and is actuated by the ordinary solution of the bichromate of potassium and sulphuric acid. The novel feature consists of a bellows, by which a stream of bubbles of air ascends through the liquid between the plates and removes the products of polarization from their surfaces. With a battery of this kind

contained in a box six inches square, a wire of platinum of about one-thirtieth of an inch in diameter and eighteen inches in length was brought to a red heat.

A convenient form of what is called Lockwood's Improved Gravity Battery was exhibited by the American District Telegraph Co. In this battery, crystals of sulphate of copper occupy the lower part of a tall glass cell filled with dilute sulphuric acid. In the midst of these the negative plate is immersed, while the zinc element is placed in the upper part of the cell. The crystals of sulphate of copper gradually disappear in the course of a year in the ordinary use of the battery, and an equivalent of sulphate of zinc is uniformly diffused through the upper part of the liquid.

Besides these a variety of instruments were exhibited for applying electricity as a remedial agent. Some of these were ingenious and well adapted to the purpose for which they were intended. It is proper, however, to observe that the Judges do not vouch for the claims set up for these instruments by their inventors as curative agents. If electricity be in some cases beneficial, it will follow that in others it will prove detrimental.

Electro-Dynamic Engine.

The object of this invention is to produce a motive power from electro-magnetism applicable to industrial purposes. From the time of its first invention, in 1830, by Prof. Henry, attempts have almost continuously been made to so improve this machine that it might be substituted for the steam-engine; but all attempts of this kind are necessarily futile, since the evolution of power from the action of acid on zinc is far more expensive than the evolution of an equivalent amount of power from the burning of coal or wood in atmospheric air. The engine, however, may be successfully applied in certain cases in which the expense of power is a secondary consideration, such as, for example, the driving of sewing-machines and giving rapid motion to certain philosophical instruments for experiments in light, electricity, &c. A number of small machines of this kind were exhibited, but they presented nothing important in the way of originality of construction or of application.

Submarine Cables and Insulated Wires.

Samples of submarine cables were exhibited by the India-Rubber, Gutta-Percha, & Telegraph Works Co., London, by Siemens Bros., London, and by the Telegraph Construction & Maintenance Co., also of London. Of the excellence of one of the cables of the first mentioned of these companies, Sir William Thomson testifies, from personal knowledge, that he found the Direct Spanish Cable perfect after being laid for six months. The specimens exhibited by Messrs. Siemens represent cables which have been laid for the River Plate & Brazil Co. and the Direct United States Cable Co., which are now in operation between Rio Janeiro, Santos, Santa Catarina, Rio Grandé da Sul, and the southern frontier of Brazil, and Ireland, and the United States. The specimens of the third mentioned company represent cables which have been laid by this company in all parts of the world, including the Atlantic Cables of 1865–66; those joining England and France with Malta and Alexandria; the Red Sea and Bombay with England; the cable connecting India with China and Australia; lastly, that connecting Australia with China. The excellence of these cables, as well as those of Siemens, has been tested by Sir William Thomson.

Among the insulated wires, that prepared by Austin G. Day, and denominated kerite insulated conductors, is highly recommended. The wire in this case is covered by an insulator termed kerite, an artificial caoutchouc, in which the raw rubber is replaced by tar or asphaltum, which, combined with animal and vegetable oils, is vulcanised by sulphur.

It may be mentioned in this connection that samples of galvanised telegraphic wire of a superior quality were exhibited by Washburn & Moen, of New York.

We may also place in this class insulating supports. Among those exhibited, Brook's insulator is mentioned with special commendation. It has great strength, is safe against damage from missiles, and possesses insulating qualities in case of rain, snow, and fogs, superior to any other appliance of the kind known to the Judges.

The British Joint Stock Company for Telegraph Supplies also exhibited a series of insulators of excellent quality for supporting telegraph-wires.

Telegraphs.

The most important applications of electricity were those to telegraphing, fire-alarms, burglar-alarms, and various indicators. The extension and improvements of these applications have been far greater in this country than in any other.

We may first mention Edison's American Automatic Telegraph, which gives, on lines of all lengths insulated on poles in the air, speeds of working which are from two to ten-fold that of any other system hitherto in use. "I have myself, in Philadelphia," said Sir William Thomson, "witnessed the receiving, in fifty-seven seconds, of 1,015 words from New York." This telegraph is founded on the principle originally introduced by Bain, that of the chemical action of an electric current on a slip of paper impregnated with a solution of ferrocyanate of potassium. The messages to be transmitted are previously transferred to a series of long slips of paper in which the letters are indicated by perforations representing the dots and spaces of the Morse alphabet. These slips are placed on the circumference of a metallic cylinder connected with the line, and pressed down by a flat spring having a projecting point, which, passing into the holes, completes for an instant the circuit, and thus, by the chemical action of the current, marks the characters on a slip of prepared paper passing over a cylinder at the farther end of the line. The rapidity of the transmission of the prepared messages is scarcely limited by anything else than the rapidity with which the paper can be passed over the surface of the roller. For the rapid stamping of the holes in the paper or preparation of the message for sending, a finger-board with letters on it is used. As a number of persons may be employed at the same time in preparing different parts of a long message, a great amount of intelligence may be transmitted through a single wire in a given time.

Duplex Telegraph.

The remarkable invention by which two messages can be sent, at the same time, in different directions through the same wire, is claimed by different persons. The first exhibition of this method of telegraphing is referred to Dr. Gintl, Director of State Telegraphs in Vienna. It was, however, much improved by Carl Frieschen, of Hanover, and also, in 1872, by J. B. Stearns and Dr. Farmer, of Boston, Massachusetts.

The conditions necessary to be fulfilled in duplex telegraphing are as follows: The receiving instrument must be so contrived and so connected with the earth and the long line that, while remaining wholly unaffected by the movements of the transmitting key at the home station, it will respond to every movement of the key at the distant station. To produce this effect we may suppose the main line to be charged with two batteries, one at either end, and that the current of each of these batteries is divided into two half currents, one going into the line and the other into a side circuit composed of coils of fine wire, so increased in length as to offer a resistance just equal to that of the line itself. These divided currents are passed through receiving and transmitting instruments furnished with double coils, to transmit the current in opposite directions and thereby neutralise the effect of each battery on its own transmitter, while a slight increase in the power of the battery destroys the equilibrium of the distant receiver and produces the motion necessary to the exhibition of the signal.

A duplex telegraph was exhibited by the Western Union Telegraph Co., of New York, which is commended for the simplicity of the arrangement of the keys and receivers, by which messages may be sent at the same time without liability to error.

The Quadruplex Telegraph.

The first step toward the invention of the quadruplex telegraph, or that in which four or more messages are sent at the same time through the same wire, was made by Dr. J. B. Starke, of Vienna, in which he sent two messages

simultaneously in the same direction, which was a step in advance of the duplex system, since in that the messages were sent simultaneously in opposite directions. This method of sending simultaneous messages in the same direction consists in sending from the transmitting station, by means of two keys, two currents of different intensity, which, at the distant station, set in motion two corresponding relays. This system, combined with that of the duplex, furnished the means of transmitting four messages, two each way simultaneously, through the same wire. In the same way, by sending simultaneously three or more currents, each of different intensity, in the same direction through the same wire, as many different messages may be transmitted at the same time; but when this system is extended beyond the quadruplex the arrangement becomes very complicated, and is consequently liable to derangement and error. Various contributions have been made by different inventors to the practical success of the system, but the improvement to which is principally due its extensive introduction into practice is that of Mr. J. B. Stearns, of Boston, combined with that of Mr. F. A. Edison, of New Jersey. The quadruplex apparatus, in its latest improvement, is now worked by the Western Union Telegraph Co. upon thirty-five circuits, with perfect success. Among other combined circuits that from New York to Chicago, a distance of one thousand miles, had been working for several weeks without interruption, giving simultaneous communications at full speed, with an average daily work exceeding fifteen hundred messages. The details of this system are too complex to give any idea of them in an explanation of this kind, and without diagrams. We refer, however, for the best account hitherto published of this and all other telegraphs and their applications, to a work by George B. Prescott, electrician of the Western Union Telegraph Co., published by D. Appleton & Co., New York.

Autographic or Copying Telegraph.

The autographic or copying telegraph, which gives a fac-simile of the original written message, requires no skilled labour in the transmission of despatches, the original copy being prepared by the sender and the received copy being in a condition for immediate delivery. It has, however, never been employed to any considerable extent in the transmission of messages, because the rate of profitable work has been too slow. It has lately, however, been employed in transmitting the lines of equal barometrical pressure for the use of the Meteorological Signal Office of the United States army. The process consists in writing or drawing, on silvered paper prepared for the purpose, the message or diagram to be transmitted, in a bold hand, with a fluid which, when dried, is a non-conductor of electricity. The metallic paper thus prepared is attached to the circumference of a metallic cylinder connected with the line, which revolves synchronously with another cylinder at the farther end of the line, around which is a sheet of ordinary paper imbued with the ferrocyanate of potassium. Both cylinders have, besides a rotary motion, a lateral one, given them by a screw on the axis. The current from the battery is transmitted to the metallic paper, and by it to the line, from a point or stylus, and as the two cylinders revolve a line is marked on the distant one with a break in it at the point corresponding to that at which the point of the stylus passes over the writing or drawing on the silvered paper attached to the first cylinder. A series of these lines, like those produced by a ruling-machine, covers the whole paper, with the exception of the lines of writing or drawing, which are thus exhibited by contrast on the surface of the prepared paper. The impression may be reversed, and the writing shown in a darker hue than that of the ordinary colour of the paper. The latest improvement on this process is that by W. E. Sawyer, of Washington, D. C. This consists in writing the original message on ordinary writing paper, with common ink containing a little glycerine to prevent drying too rapidly; the writing is then dusted with powdered shellac and laid face downward upon a plate of clean zinc. The plate and paper are next passed between heated rollers, by which a reversed copy of the writing is transferred to the zinc plate in non-conducting lines. This metallic plate is finally bent around the cylinder attached to the line, in place of the silvered paper previously mentioned.

The Electric Telephone and Multiple Telegraph.

The idea of transmitting sounds to a distance by means of electrical currents has been for several years before the world, and the idea of extension of this to telegraphy was evident, though no one had thought it could lead to practical results. But the idea of a multiple electrophonic telegraph transmitting simultaneously several different musical notes for the simultaneous transmission of different messages by one wire, is an invention of high scientific character promising admirable practical results. For the honour of this invention there are two claimants, Mr. Elisha Gray, of Chicago, Illinois, and Mr. Alexander G. Bell, of Salem, Massachusetts. These inventions are independent of one another, and different in the method of producing the result. In the telegraph of Mr. Gray several series of waves or impulses are simultaneously transmitted through a single wire. These impulses are excited by interruptions in the current produced by tuning-forks of different pitches, and excite, at the farther extremity of the line, corresponding variations in tuning-forks of the same pitch. Thus, if four or five tuning-forks are vibrated at the same time at one end of a line, each will excite vibrations in its corresponding fork at the other end without affecting the other forks. The exhibitors of this telegraph inform the Judges that they are now able to equip lines for actual business with a capacity for carrying, through one wire, eight messages simultaneously, and there is no reason why the number may not be increased to sixteen. This telegraph may be made self-recording, or may be worked forward by relays through greater lengths of line than the insulation allows in one circuit.

The telephone of Mr. Bell aims at a still more remarkable result,—that of transmitting audible speech through long telegraphic lines. In the improved instrument the result is produced with striking effect, without the employment of an electrical current other than that produced by the mechanical action of the impulse of the breath as it issues from the lungs in producing articulate sounds. To understand this wonderful result, suppose a plate of sheet-iron, about five inches square, suspended vertically before the mouth of the speaker so as to vibrate freely by the motion of the air due to the speech, and suppose also another iron plate, of the like dimensions, similarly suspended before the ear of the hearer of the sound, and between these, but not in contact with them, is stretched the long telegraphic wire. Each end of this wire is attached to two coils of insulated wire surrounding a core of soft iron, the ends of which are placed near the middle of the plate, but not in contact with it. These four cores are kept in a magnetic condition by being attached at each end of the line to the two poles of a permanent magnet. Now it is evident that in this arrangement any disturbance of the magnetism of one of the permanent magnets increasing or diminishing it will induce electrical currents, which, traversing the long wire, will produce a similar disturbance of the magnetism of the arrangement at the other end of the wire. Such a disturbance will be produced by the vibration of the plate of soft iron due to the words of the speaker, and the current thus produced, changing the magnetism of the soft iron cores, will by reaction produce corresponding vibrations in the iron plate suspended before the ear of the hearer. The vibrations of the second plate bing similar to those of the first will reproduce the same sounds. Audible speech has, in this way, been transmitted to a distance of three hundred miles, perfectly intelligible to those who have become accustomed to the peculiarities of certain of the sounds. All parts of a tune are transmitted with great distinctness and with magical effect.

This telephone was exhibited in operation at the Centennial Exhibition, and was considered by the Judges the greatest marvel hitherto achieved by the telegraph. The invention is yet in its infancy, and is susceptible of great improvements.

The Printing Telegraph.

This telegraph, which sends messages in the ordinary letters of the alphabet, was invented in 1846 by R. E. House, of Vermont, but has since been improved by David E. Hughes, of Kentucky, and by George M. Phelps, of Troy, New York. The objection to this mode of telegraphing has been the slowness of the operation. In the most improved instruments of this system of telegraphing,

however,—those of Phelps,—sixty words have been transmitted in a minute. A printing telegraph instrument, by Anders, of Boston, very well adapted for private use between places of business and dwelling houses, was reported favourably upon at the Centennial Exhibition. It is of simple construction, and little liable to get out of order; no voltaic battery is used, the signals being transmitted by magneto-electric action. Another printing telegraph for similar purposes was exhibited by Gray, of Chicago. It differs from the preceding instrument principally by being actuated by a gravity battery of eleven small cells for a line of forty miles, and four similar local batteries for each receiving station. A third instrument of this class was by Phelps and Philips, of Philadelphia. It embodies, in a compact form, a receiving apparatus to indicate by letters on a dial, a transmitting apparatus with a key adapted to the same, and also a call-bell. It operates rapidly and efficiently, does not require an experienced operator, and is well adapted to general use.

Burglar Alarm and Automatic Annunciators.

The object of this form of telegraph is by a series of wires, connected with the outer doors and windows of a house, to give intelligence in a sleeping chamber of any opening of these apertures at an unusual hour. The arrangement is such that the number of strokes on a bell specifies the exact place of disturbance. Another feature of the arrangement is such that an indicator points out the fact as to whether all the windows and doors of a house are closed.

One of these instruments was exhibited by George A. Dowden, of Newark, New Jersey, and another by the Burglar Alarm Telegraph Co., of New York. The latter was specially applied to bank safes with a peculiar and effective arrangement, which, by double panels, with sheets of tin foil between, closing an electrical circuit when the panel of the door is pierced, or broken, or cut into, gives the alarm.

Automatic Fire Annunciator.

In this, two metals of different expansibility make a contact when heated to a certain degree, by which an electrical current is put in motion and a bell rung. The arrangement is very simple and much less liable to get out of order than that in which a circuit is closed by means of the expansion of mercury heated in a glass tube with a bulb.

Electrical Annunciator.

The object of this telegraph is to send messages from the chambers of a hotel to the office. In the annunciator exhibited by Watts and Co., of Baltimore, nine separate calls may be made, for as many different articles, by touching the respective buttons opposite to which the different messages are written.

Fire-Alarm Telegraph.

The object of this telegraph, as the name indicates, is to receive at a central office intelligence of a fire in any part of a city, and from the office to give an alarm to the various fire companies by striking the church bells in accordance with an adopted system of associated sounds and intervals of silence. It was originally invented by Moses G. Farmer, of Boston, in 1857, and now, with many improvements and developments, is used in seventy-eight cities in the United States and Canada. The alarm, from a place near the fire, is transmitted to the central office from a small magneto-electric apparatus, inclosed in a box permanently attached to a wall in some accessible place, which, by turning an exterior crank, sends an induced current to the central office, which calls the attention of the attendant by ringing a bell. The church bell is struck by the motive power of a descending weight or by that of the city waterworks. The power is brought into operation by the attraction of the armature of a relay magnet, which, by removing a detent, enables the power to act. This telegraph was exhibited by J. N. Gamewell and Co., of New York.

Another fire-alarm telegraph was exhibited by the National Fire-Alarm Co., of Richmond, Indiana, and was commended for good design and construction.

Railway Signals.

Another invention under this general class is intended to give information at the terminus of a railway as to the position of cars on the road at a given time, or of accidents, as the case may be, by an electrical circuit through the rails of the road and the axle of the carriage. An award was recommended for this invention on account of the usefulness of the object proposed and the promise of practical success which the details of the method justify.

Magnets.

A magnificent magnet, constructed on the plan of M. Jamin, was exhibited, carrying a weight of 450 kilogrammes, or about four times its own weight. This magnet was constructed of plates of steel of the form of a horseshoe magnet with elongated limbs. This form of the magnet is the result of a series of experiments by M. Jamin, of Paris, on the distribution of magnetism in plates of hardened steel. For determining this distribution he employed a small soft iron cylinder or pencil, surrounded by a coil of insulated wire, the ends of which were attached to a galvanometer. When the rounded end of this cylinder was applied to a point on the surface of the magnetised plate and then suddenly withdrawn, the deflection of the needle of the galvanometer, due to the electrical current induced in the wire, measured the relative intensity of the points touched. From the investigations thus made the following conclusions were deduced:

First. The quantity of magnetism that can be contained in a magnet does not alone depend upon the average section.

Second. The distribution of the magnetism is regulated by the form and extent of the exterior surface.

Third. If the surface diminishes, the tension augments up to a certain point, after which it diminishes.

Fourth. If the surface changes but the mean section remains constant, the quantity of magnetism also remains constant.

Having established the fact that the mean section determines the quantity of the magnetism, and that the surface is that which regulates the distribution, it follows that if the magnet is made greater without increasing the quantity of magnetism the tension becomes less. In accordance with these laws it was found that when magnetised plates were placed upon each other, the magnetism of the surfaces of contact was diminished while that of the exterior was increased up to a certain limit, which depended upon the length of the plate. The power of the plate increases considerably with its thickness, but less rapidly than the thickness, so that there is a limit beyond which it remains stationary. But a plate of a given thickness has less power than two others each of half the thickness. M. Jamin was thus enabled, by employing ribbons of steel, to construct magnets carrying twenty times their own weight.

Magnetic Compass.

Abundant evidence has been afforded of the value of the improvements on this instrument, of essential use in navigation, in the floating compass of E. S. Ritchie and Sons, of Boston. The card of this compass is furnished with two magnets placed parallel to each other, the ends sixty degrees apart, on opposite sides of the meridian line. The whole is floated in a liquid not susceptible of freezing, the buoyancy of which lessens the pressure on the point of support and gives shortness of period to oscillations, thus furnishing stability in pointing out the magnetic meridian. The instrument is also commended for the perfection of its centering and accuracy of division. It is adopted for general use in the United States navy.

Ritchie & Sons also exhibited an improvement in the marine azimuth compass for use in iron ships. By means of a reflector the observer looks downwards towards the compass bowl, in taking a bearing by this instrument, and thus obtains the great advantage of seeing the numbers of degrees on the compass-card direct, instead of inverted as in the ordinary prism-compass, while it secures the further advantage of permitting the application of the mass of soft iron required in correcting the quadrantal error of the compass without impeding the use of the instrument in taking azimuths in any direction.

Another nautical compass, exhibited by the Brazilian navy, is favourably noticed. It is an azimuth compass with a repeating movement giving the means of increased accuracy of results.

Apparatus for Correcting Ships' Compasses.

This apparatus devised by Prof. B. F. Green, of the Navy Department, and which is denominated an adjustable binnacle, is intended first to serve as a convenient receptacle of a compass on shipboard, with the usual provision for protection and illumination; second, to furnish magnetic correctors, with arrangements for their convenient adjustment, so as to neutralise the magnetic force of the ship. This apparatus supplies a complete solution of the problem of the correction of compasses on iron ships, and has contributed much to the improvement of compass correction on ships in the United States navy.

It may be mentioned, in connection with this subject, that it is now tolerably well ascertained that some of the sudden and hitherto unaccountable deviations of the compass on board of iron ships are caused by the unequa. and varying diffusion of heat over the iron hull. This is a true cause of variation, and though small in ordinary cases, would probably produce effects of considerable magnitude in passing, for example, from the Gulf Stream into a polar current.

Miscellaneous Inventions.

Among these one of the most interesting is that of the Electrical Pen and Duplicating Press by T. A. Edison, of New York. This application of electricity is intended to produce an indefinite number of copies of manuscripts or drawings. This is effected by causing a fine steel needle to be projected from the point of a tracing-pen, by which the impression on the original paper is represented in a copy by a continuous series of perforations. The motion of the needle is produced by a small electro-magnetic machine held in the hand. The copies are taken by placing under the perforated paper a blank sheet, and passing over the former a cylinder imbued with printers' ink.

The Pneumatic Telegraph.

Three samples of this invention were exhibited, one by Walcker, of Paris, another by Kuntz & Co., of Stockholm, and a third by Zimber & Turtwangen, of Germany. This form of telegraph is simple and useful for transmitting a small power to a distance, for the purpose of signaling and other objects. It consists essentially of a long tube of india-rubber, lead, or tinned iron, with an elastic rubber bottle at one end and a cylindrical bellows at the other. When the bottle is compressed in the hand, an impulse is transmitted through the air to the other end of the tube, which, by expanding the bellows, moves a ratchet, giving motion to a wheel, which in turn moves the hammer of a bell, or produces other mechanical effects.

Lightning-rods.

A great variety of these were exhibited, but with one exception they were not in strict conformity with well-established principles of electrical science. The one recommended for award as being in accordance with all the established facts of electricity, was by D. Carrette Dobels, of Belgium. It consisted of a principal rod of wrought iron, which metal is a sufficiently good conductor for electricity of high tension, is cheaper than copper, and is not liable to be melted, as the latter is, by a heavy discharge of lightning. The rod is cylindrical, which form, being free from salient edges, is the best for transmitting a discharge without danger of lateral diversion. The part of the rod which is elevated above the roof is slightly tapering, to present less resistance to the wind, and the rod is covered with a coating of metallic paint, which prevents rusting, and does not interfere with the transmitting power of the conductor. It is terminated above by a single platinum point, which, from theory as well as direct experiment, is known to produce a greater effect in directing the path of a discharge than several points terminating the same rod. To insure a good connection with the earth, the rod is terminated below in five branches, projecting into moist earth or water. We would only add to these peculiarities

that an essential feature of a good lightning-rod is its intimate connection with the earth, and to make this as perfect as possible its lower end should be put in metallic connection with the water or gas mains of a city.

Electrical measuring instruments.

Among these were a variety of Galvanometers and Resistance-Coils which are commended for the excellency of their workmanship, though they involve no new principles.

Musical Instruments.

By Henry K. Oliver.

Before entering upon detailed statements as to the various musical instruments shown at the Centennial Exhibition, it may be desirable to sketch the rise and progress of their manufacture in the United States. The subject is difficult because of the scant supply of records and of historic material. With that unsatisfactory aid, and by means of traditions and reminiscences contributed by those yet living who were early engaged in the trade, the subjoined helps to more exact history are given.

Pianoforte.

This instrument, with the organ, is rightly characterized as a beautiful example of ingenuity and of skill in achieving success over all complexities of leverage between key, wire, and pipe; of most delicate mechanism in action; and of resonant power, and tonal richness in result. Though ranking above all other instruments of music in its varied social relations and influences, the origin and early and continuous history of the pianoforte are not free from obscurity, nor without controversy. Research and observation trace its leading principle, that of stretched strings, to the ancient lyre and harp. The general position and lay of the strings, in all classes of the instrument, clearly indicate this origin and relationship, the prototype harp assuming, along the line of centuries, the several forms of psaltery, dulcimer, clavicitherium, clavichord, virginal, spinet, and harpsichord,—ripening, after the lapse of more than 2,000 years, into the perfectness of the magnificent instruments of modern times, with their better materials, more exact appliances, finer adjustments, greater strength of parts, increase of compass and power, elastic responsiveness of touch, enlarged sonority, and satisfying delicacy and singing character in tone. What success has crowned these efforts is well evidenced in the splendid instruments of Broadwood and the Collards, of London; Erard, of Paris; Bechstein, of Berlin; Chickering, of Boston; Steinway, Decker, and Weber, of New York; and Knabe, of Baltimore.

By whom the first pianoforte was made in the United States is an interesting inquiry. The earliest instruments in use were invariably imported. Bishop, in his *History of American Manufactures* (Philadelphia, 1864), says that "the pianoforte, superseding the harpsichord, appears to have been first made in Philadelphia by John Belmont, in 1775," adding that "in 1785, James Julian, of the same city, announced a pianoforte of his own invention," and that "in 1790, the *Advertiser*, a newspaper of Philadelphia, says 'an ingenious artist here has completed several pianofortes, not inferior to those imported.'"

About the same date (1785), Benjamin Crehore, of Milton, Massachusetts, a manufacturer of violoncellos, guitars, &c., succeeded in manufacturing pianofortes, copying, probably, from Broadwood, whose instruments were then occasionally found in wealthy families in Boston.

The first pianofortes made in Boston were the work of Adam and William Bent, about the year 1803, though harpsichords and spinets were made in Salem, Massachusetts, prior to 1795 (the year of his death), by Samuel Blythe. One of his instruments is now in the possession of the Essex Institute, of that city, on the front board of which one reads, "Samuel Blythe fecit" (no date). The instrument is about five feet in length and thirty inches in width, its key board having five octaves.

In 1800, John J. Harkins, of Philadelphia, patented an improvement in the pianoforte, which instrument he manufactured and sold in that city under the name of "Patent Portable Grand Piano."

We next find Lewis and Alpheus Babcock, apprentices of Crehore, manufacturing pianofortes in Boston. In 1810, they entered into partnership with Thomas Appleton (afterwards a celebrated organ builder), and the brothers Hayts, Babcocks, and Appleton, Crehore, then an old man, working for them, with John Osborne as an apprentice, who, about 1814, set up in business for himself. This firm crippled by the war with England (1812–15), dissolved in 1820, the Hayts moving to Buffalo, New York. Mr. Appleton devoting his skill to organ building; and Mr. Alpheus Babcock, with the aid of John Mackay, who had invested capital in the old firm, continuing the piano-forte business in the Parkman Market building, on Cambridge Street. Within a couple of years Babcock removed to Philadelphia, continuing the business there with a German associate.

Between the years 1810–15, Robert Cowan, an ingenious Scotch mechanic, resident in Salem, Massachusetts, made several pianofortes in that city, which the writer of this article saw and played upon at Cowan's factory as late as 1822.

In 1810, Adam Stewart, a Scotchman by birth and a pianoforte maker by trade, emigrated to this country from London, where he had learned the business in the house of Clementi. He settled in Baltimore, where, with the aid of his brother, James Stewart, he made several instruments. A few years later, Osborne, becoming acquainted with James Stewart, induced him to remove to Boston. With them Timothy Gilbert and Jonas Chickering, the latter of whom afterwards achieved a wide and most deserved celebrity, were apprentices. Osborne and Stewart parting, the new firm of Stewart and Chickering was established, February 1823,* in a building next east of King's Chapel Burying-ground, on Tremont Street. In 1827 Stewart returned to England, joining the house of Clementi & Co., and Chickering continued alone till 1830, when the firm of Chickering and Mackay was created, continuing till 1841, when it was dissolved by the death of Captain Mackay, who was lost at sea, and Mr. Chickering conducted the business alone. Entering upon a career of successful enterprise, he gave an unprecedented impetus to the trade, and, creating a widely-spread demand for its products, allured capital and skill, awakened an exciting and effective rivalry, provoked many and important improvements, and inseparably interwove his name into the history of this great branch of mechanic skill.

Following the lead thus begun came a long line of manufacturers, more or less succesful. Among the former were Timothy Gilbert, E. R. Currier, Brown & Hallett, Hallett & Cumston, George Hews (honoured for his skill and loved for his virtues), the Woodwards, and Hallett & Davis, the latter of whom has passed a half century in the business. To these should be added Albert W. Ladd, of whose instrument at the International Exhibition (1855), with its "over-strung bass" wires (claimed by Mr. Ladd as his invention in 1853), M. Fétis spoke in terms of high praise, as remarkable for its power and equality of tone.

In New York, nearly all the piano-fortes up to the year 1820 were square, imported from England by John Jacob Astor, being from the manufactory of Broadwood or of Clementi. These were to be found only in the homes of very wealthy citizens. But in that year several expert and skilful foreign artisans immigrated, and established factories in that city, among them being Geib, who was also, we believe, an organ-builder, Robert and William Nunns, Adam Stodart, J. B. Dunham, Horatio Worcester, and Bacon & Raven. These became well-known and extensive manufacturers, occupying nearly the whole trade, and rearing many well-trained artisans. As a general rule, the New York makers were unfavourable to the use of the iron frame, believing it not promotive of purity and clearness of tone. None of the more prominent among them made any attempt at its introduction into their instruments.

Henry Steinway, the founder in New York, in 1853, of the house of Steinway and Sons, emigrated in 1850 from the Duchy of Brunswick, where he was born in 1797. He brought with him four sons, he and they at first working at their trade of pianoforte making with different manufacturers. Commencing with prudent caution, and gradually, as success justified, enlarging their

* An instrument made by Chickering in 1823, and in excellent order, was on exhibition at the stand of Chickering and Sons in the Main Building during the Exhibition.

facilities they, in 1855, entered upon a very extensive line of business, expanding yearly to wider and wider dimensions, enrolling themselves among the great manufacturers, and achieving an eminent and widely-recognized celebrity. There was also, in the same city, and increasing number of manufacturers of note, who, by persistent industry and skill, achieved reputation and success, so that now New York supplies a very large demand by an array of instruments of well-merited character for excellence in-workmanship and in all the qualities that constitute a thoroughly good article.

In Philadelphia, between 1819 (when the business seems first to have taken firm root) and 1825, the prominent names appear to have been James Taws, C. Pommer, John Loud, C. F. L. Albrecht, Conrad Meyer, yet living, and Bassert and Schomacker. Since that date are recorded the names of John and Thomas Loud, Fred. W. and C. Pommer, Schomacker, the Schomacker Manufacturing Company, the Albrechts, and Conrad Meyer and Sons. Conrad Meyer, the founder of the latter house, was born in Hesse-Cassel in 1793. He immigrated to Baltimore in 1819, commencing his business at once of a pianoforte maker. In 1823 he removed to Philadelphia, and has since continued there, associated with his sons, he himself being now (1876) the oldest living manufacturer in the United States.

As early as the year 1810, this branch of manufacturers appeared in Baltimore, Adam Stewart, a Scotchman, and a pianoforte maker by trade, having at that date begun business on a small scale. In the year following, his brother, James Stewart, of the same trade, also settled in that city. In 1812 the brothers joined in partnership, and turned out several instruments, one of which is now extant. James Stewart afterwards, in 1819, joined John Osborne in Boston, the latter having bought out the stock and fixtures in Baltimore, the war with England (1812–15) breaking up their business.

There appears also to have been in that city in the year 1819 another establishment, carried on by William Hartge, in which appeared, about the year 1830, Mr. William Knabe, an immigrant from the Duchy of Saxe-Weimar, Germany (now deceased), who learned his trade in Gotha. In 1837 he founded the existing house of William Knabe & Co., which has built up a deservedly successful business of the largest dimensions, involving a capital of half a million of dollars and employing about four hundred artisans. Their instruments hold a high rank and supply a large demand.

Between 1825—when iron began to be used as a resistant to the pull of the strings and a strengthener of the wooden frames in general use, and the present day, many important improvements, originating with ingenious manufacturers in both America and Europe, have been made in nearly every part of this instrument, so that in the modern grands, squares, and uprights one can hardly recognize the prototype of the early years of the century. Among the most valuable of these improvements are the iron frame, the circular scale, the over-stringing (claimed by several manufacturers as original with them), the increased size, strength, and solidity of the instrument and of its strings, with their greater sonority, brilliancy, and carrying power, yet without sacrifice of richness, purity, delicacy, and singing quality, and the securing of an almost perfect responsive elasticity of touch. To these may be added the greatly increased compass of the instrument from the five octaves of 1800 to the seven and one-third of the present day.

The piano-forte has now its three distinct forms of grand (sub-divided into concert and parlour-grand), square, and upright; the square being the most common form in the United States, and the upright in Europe, as it will doubtless be here, its compact shape, its capabilities and powers, as well as its facility for transportation, aiding its more extensive adoption. The old objections to the upright pianoforte, on the score of weakness in construction and uncertainty in keeping in tune, have been obviated by modern skill and improvements; and it is rapidly gaining favour.

At the Centennial Exhibition at Philadelphia there were presented by upwards of sixty manufacturers about two hundred pianofortes, of the four varieties of concert-grands, parlour-grands, squares, and uprights. Most of these were of American production, some few from the British provinces, and some from Europe. Taken as a whole, the collection was entitled to the very highest praise, while of many of them it would be difficult to speak in adequate terms of commendation, and difficult too to distinguish between the

best of the best makers; and while there were many very excellent instruments among those presented by foreign exhibitors, we feel fully warranted in saying that, for superior quality in tone, impartial evenness in distribution of power along the whole scale, sharply responsive elasticity of touch, fidelity and taste in workmanship, with normal excellence in materials employed, and valuable practical improvements in great variety, the American exhibit presented instruments responding in all particulars to every requirement that can be made of this department of art.

Of foreign exhibitors, there were from Germany, 10; England, 4; British Provinces, 7; France, 3; Russia, 2; Spain, 1; Switzerland, 2; Sweden, 1; Brazil, 1; Austraila, 1,—total, 32; and the American being 32, gave a full total of 64 exhibitors of pianofortes alone, the number of instruments being upwards of 200.

Of church-organs there were 6 exhibitors; of parlour-organs, 12; and a very large number in the departments of instruments for orchestras and military bands. These exhibits were all displayed in various parts of the Main Building, where it was manifest that no proper testing could be made, both crowd and noise preventing. It may be here stated that the subject of the musical instruments, string, wind, and pulsatile, was assigned to the Judges of Group XXV., consisting of ten members, to four of whom, Julius Schiedmeyer, of Stuttgart, Germany, a manufacturer of pianofortes and harmoniums, with experience as a Judge at Expositions in Europe; George F. Bristow, Professor of Music, of New York: F. P. Kupka, of Vienna; and Henry K. Oliver, of Massachusetts,—the last two being amateurs,—the immediate examination and testing were deputed.

The duties devolving upon these four, of whom only two were constantly on duty, were exceptionally arduous, demanding versatility and variety of experience in the several departments, and severely taxing brain and body. It was suggested that their numbers be increased. It being, however, too late, authority was given to employ experts when deemed advisable or necessary. This was done with orchestral and band instruments only.

At their meetings for organization and arrangements it was decided, in relation to all instruments (excepting church-organs), 1st, that the testing should be made in the hall of the Judges' Pavilion; 2nd, that the several exhibitors might select, each from his own exhibit, such instruments, not exceeding one of each variety, as he was willing to present for judgment; 3rd, that each exhibitor should be invited, prior to the testing of his instruments to make such statements to the Judges as he desired, in reference to his claims and to the qualities of his instruments; 4th, that a figurate scale should be adopted in determining the qualities of pianofortes, descending from six downward, according to their degrees of excellence in tone, evenness of distribution of power along the scale, or equality, general quality as a whole, and elasticity of touch; and that practical valuable improvements and workmanship, neither of which could be numerically expressed, should receive careful consideration in making up awards; 5th, that all piano-fortes, the average of whose several markings should amount to three or upwards, should be recommended for awards. But one objection appeared against this method, a very serious one indeed, which, however, it was believed a sense of honour and justice would obviate. It permitted a partisan Judge, should there be one, to practice favouritism by marking high or low, as the exegencies of an object to be accomplished might prompt. This general method being determined, the testing took place, all the instruments, excepting the church-organs, being brought to the Judges' Hall. The church-organs were examined at their several locations in the Main Building, after the retiring of the crowd.

The method of award adopted by the Centennial Commission, of recognizing merit wherever found, whether in "originality, invention, discovery, utility, quality, skill, workmanship, fitness for the purpose intended, adaptation to public wants, economy, and cost," opened a very wide door, and led to a liberal distribution of awards. It must be borne in mind that the Judges themselves had no power to make these awards, their only function being, after proper testing and examination, to "*recommend to the Cetennial Commission for award*" whatever exhibits might, by such Judges, be deemed worthy thereof.

An instrument of complicate action, called a violin-piano, in the shape of a grand pianoforte, was exhibited by George Greiner, of Sacramento, California. It was an attempt to produce from the wires the tonal effects and continuity of tone of instruments of the violin class. The same experiment has been before not successfully attempted, both in England and in France. At the Paris Exhibition of 1867, M. Baudet, a Frenchman, exhibited a similar instrument; but every attempt of this sort since the seventeenth century has failed, the upper part of the strings giving the tone of the hurdy-gurdy, and not of the violin; the middle strings giving those of the harmonium; and the lower and by far the most pleasing, giving some semblance to the tones of the violoncello, yet not so fully characteristic as to deceive the listener. The instrument in question received a great deal of attention from the Judges, and afterwards, on appeal of the exhibitor, was re-examined by the proper Judge on appeals, and by five experts, with entire unity of adverse opinion. What may be the result of continued effort in a field of doubtful promise or utility it is not possible to predict.

There was another pianoforte, exhibited by Achille Perise, of Italy, with a very ingenious apparatus connected with its keys, by which improvisations of any pianist may be recorded, as he plays them, on paper adapted to the purpose and then transferred by copying upon ordinary music-paper.

M. Thibouville y Lamy, also, of Paris, exhibited a mechanical apparatus of much ingenuity, called a pianista, which can be applied to organs or pianos. It is an instrument with a key-board adaptable to that of a piano or organ. Its function is to play on these instruments mechanically, by means of perforated cardboard, and it executed music in great variety with entire exactness and much expression. The mechanism of the pianista is very solid, and the manner of using the instrument exceedingly simple, the book of perforated cardboard representing the piece of music to be played having only to be placed on top of the pianista, already adjusted to any pianoforte, and then, by the turning of its handle, the cardboard is put in motion, performing the music and requiring no guiding, but forming itself into a book again as it moves along. It is the most ingenious and perfect piece of mechanism yet invented for playing pianos and organs automatically.

The oldest pianoforte on exhibition was that of Johannes Christian Schreiber, made in 1741.

Very excellent pianofortes and parlour organs were also exhibited by Julius Schiedmeyer, of Stuttgart; but no award was made, as he himself was one of the Judges on musical instruments.

The result of the test of the pianofortes was, that of the whole number presented for trial, taking the average of the numbers given on the points before named, there stood the test 23 grands (12 concert and 11 parlour) out of the 31 tested, or about 74 per cent.; 25 uprights out of 28, or about 90 per cent.; and 28 squares out of 39, or about 72 per cent. These percentages clearly indicate the increasing success following the increased attention given to the manufacture of grands and uprights, especially the latter, as compared with squares. Comparing, also, the whole number that stood the test with the whole number tested, it appeared that 76 out of 98, or 77½ per cent. were successful. Among them are included both foreign and home-made instruments, those tested being selected by the several makers from their own several exhibits.

Organ.

This noble instrument, king in the realm of music, complicate as it now is, yet of easy control under the hands of experts, fertile in varied symphonious effects, giving with equal and satisfying success the gentlest and most sympathetic tones, as well as complete and sublimely-full utterances of musical inspiration, has a remote and continuous history, into the minute details of which it is not necessary here to enter, except so far as the manufacture of the instrument in the United States is concerned. Originating in rude form, in the earliest Christian centuries, it is referred to in a Greek epigram of the fourth century as "with reeds of a new species agitated by blasts of wind that "rush from a leathern cavern beneath their roots, while a robust mortal, running "with swift fingers over the concordant keys, makes them smoothly dance and "emit harmonious sounds." "The Hydraulicon," or "water-pipe organ," into which, by some unknown method, the air was introduced by water-pressure,

gave way in the sixth century to the wind-organ. This, with "its loud sounds "produced from divers pipes," had movements made of wood, which, "pressed "down by the fingers of the player, produce the most pleasing and brilliant "tones." This not very lucid description evidently points to the organ in its elemental state. In the seventh century it found its way into the church, and becoming known in Western Europe, grew rapidly into favour and general church use, though having but few pipes and fewer keys, and requiring the united work of several men that

"all the wind be pressed
In the close confines of the incumbent chest."

It is matter of wonder that an instrument whose extraordinary capabilities have been so completely developed within the last few centuries should have remained thus long in so imperfect a condition. Even in the twelfth century its compass did not extend beyond two octaves, half-notes being then first introduced; nor were registers, without which no variety of stops could be secured, introduced till the seventeenth century. Pedals had, however, been introduced before that period. From the Reformation to the reign of Charles I., but little mention of this instrument was made in England. During his reign prejudice ran so strongly against the use of any instruments as aids in church music that nearly all the organs in the kingdom were destroyed, and organists driven to other employments for support, a deep-seated hatred by the Puritans for all forms of worship of the Established Church running to such extremes that Government was petitioned "to put down all cathedral churches "with their piping of organs, ringing of chime-bells, and squeaking of chanting "boys." At the Restoration a change took place; but, as expert organ-builders were not to be had in England, foreign artisans were summoned, the most celebrated being Bernard Schmidt, who restored the art and supplied many skilled workmen. This spirit of opposition came with the early settlers of New England, whose inveterate and persistent opposition to its use in public worship extended to a period within the memory of many now living, with the singular inconsistency of permitting the use, in public praise-service, of contra-bassos, violoncellos, bassoons, clarionets, and even violins. In 1810 there were in the city of Boston, then containing about 30,000 people, but five organs in the churches, and in 1817 there were but eight, a gain of only three in seven years. The clergymen of the olden times had grave doubts whether instrumental music could "without profanity be introduced into the churches of New England "for the worship of God." It is known that Thomas Brattle, of Cambridge, Massachusetts, in his will (1713) bequeathed his organ (probably a parlour-organ) to the Brattle Street Church, in Boston, "if said church would accept thereof." But the church refused to do so, and the organ went, as provided in case of such refusal, to King's Chapel, in the same city. Had it been there refused, it was to go to Harvard College. This instrument was used at the chapel till 1756, when it was replaced by one imported from England, after approval, it is said, by Handel. The first Brattle organ is yet in use at the chapel of the Episcopal church in Portsmouth, New Hampshire, being now about one hundred and seventy years old, and, after some repairing, in good order. Of this second organ of King's Chapel the following notice appeared in a Boston paper of August 30, 1756: "We hear that the organ which lately "arrived from London for King's Chapel will be opened on Thursday next in "the afternoon, and that said organ, which contains a variety of curious stops, "is esteemed by eminent masters to be equal, if not superior, to any of the same "size in Europe."

Eighty years later, another organ for the Brattle Street Church, made in England, by Greene, arrived in due time in Boston outer harbour. But violent opposition yet existed, and the opponents sought to prevent even its landing, offering, through their minister, to the master of the ship, to save him harmless and make good all losses if he would throw overboard all the cases in which the instrument was packed. The clergyman declined interfering; the dreaded instrument was duly put up, and, conquering all prejudice, held its place till 1872, when the church was removed, and a new organ by the Hooks and Hastings succeeded it. It was an excellent instrument in all respects, of two manuals, sixteen stops, and over a thousand pipes.

The first organ made in America was one by Edward Bromfield, of Boston, in 1745. In 1752 Thomas Johnston built another for Christ Church, in the

same city. Another was built by him, in 1754, for St. Peter's Church, in Salem, Massachusetts. This manufacturer, dying in 1768, was succeeded by Dr. Josiah Leavitt, once a practising physician of Boston, but whose strong taste for the mechanics of music induced him to relinquish his profession and devote himself to organ building, which he continued for many years. The next manufacturer in date was Thomas Pratt, of Massachusetts, who was in the business in Boston from 1800 to his death in 1833. Contemporary with him (but in business as early as 1805) was William M. Goodrich, esteemed the "father of organ building in New England," who established a reputation in the art so deservedly high by the fidelity of his work, the accuracy of his voicing, and the excellent quality of the tones of his instruments, that during his career but three foreign organs were imported into Boston. Associated with him afterward was his brother, Ebenezer Goodrich, and later, Thomas Appleton, many of the best organs of that day being the product of these manufacturers. The elder Goodrich died in 1833, Mr. Appleton continuing in the business and building many excellent instruments. He died in 1873 at Reading, near Boston, where in the latter part of his life he carried on his work.

About the year 1820, two young brothers, Elias and George G. Hook, of Salem, Massachusetts, the elder of whom had acquired a knowledge of the art under the Goodriches, commenced the manufacture of organs in that city. From the smallest beginning, and relying wholly upon thoughtful study and mechanical fidelity, they gradually enlarged their operations, and, removing to Boston for a larger field, have achieved a well merited and widely spread renown. The firm title is now that of E. and G. G. Hook and Hastings. Their organs, exclusive of those built in the earlier portion of their business experience, number nearly 900 up to 1877, including many of the largest dimensions, and establishing their reputation as among the best artists of the world.

In New York, Adam Geib commenced the business as early as 1760, and seems to have been very successful, according to the standard of his day in this country. His son, John E. Geib, succeeded him, turning out many good instruments, one of which was erected in the North Church, in Salem, Massachusetts, remaining there from 1808 to 1847, when it was replaced by another instrument, built by Simmons and McIntyre, of Boston, and having more of the modern advantages. Geib also built various instruments for several churches in New York. About the year 1812, Thomas Hall started in the same city, continuing the business till 1875, the year of his death, at eighty-two years of age. He served his apprenticeship with a Mr. Loew, an English immigrant and organ builder of much excellence, who established his business in Philadelphia early in the century. On the death of Mr. Loew, Mr. Hall succeeded him; but he seems to have transferred his establishment to New York, and to have had among his young noviciates in the trade Henry Erben, who, having served out his full time, became a partner in 1824, though but for a few years, since about the year 1827 he started a factory of his own, which in the half century since expired has attained high rank and become renowned all over the land for its excellent instruments, about 700 having been turned out up to the present date. The firm, now Henry Erben and Co., made no exhibit at the Centennial Exhibition.

The house of Jardine and Sons, which also made no exhibit, but is here introduced historically, was originated by George Jardine, who, after serving his apprenticeship with the great London firm of Flight and Robson, settled in New York in 1837, where his brother had previously established himself as a pianoforte maker. He had a thorough knowledge of music and its mechanics, acquired after many years practice and experience, and, introducing many improvements and a variety of new stops, gradually built up a well merited reputation. The instruments of the firm are to be found all over the United States, and have excellent reputation for mechanical ability, solidity of construction, and desirable quality of tonal effects. They have built, of all sizes, about 700 organs.

Other prominent organ builders in New York are now Erben and Willson, Labaugh and Kemp, J. H. Odell and Co., and H. L. Roosevelt. The last only had an instrument at the Exhibition. Its deservedly high rank is mentioned elsewhere.

Something curious in the method of supplying air to the bellows of an organ is the method used at the organ of St. George's Church, New York. An iron tank, holding ten thousand gallons, is placed one hundred and fifty feet up in the steeple, and one of equal capacity at its base. During the week, water is gradually pumped up by a small steam engine. The power generated by the water pressure works the bellows, then falls into the lower tank, is pumped up again, and so goes on in perpetual round.

In Philadelphia, according to Bishop's *History of American Manufactures*, "an organ was ordered for Christ Church, from Philip Feyring, who had "previously built one for St. Peter's." But where Mr. Feyring worked the author does not say. This instrument was in use from 1766 to 1833. It had three banks of keys, pedals, twenty-seven stops, and sixteen hundred and seven pipes. A few years later, Mr. D. Taneberger, a Moravian at Litiz, in Lancaster County, built an organ for the German Lutheran church in Philadelphia. In 1795 John Rowe commenced the business in the same city, and continued it to 1812, the year of his death. About the year 1795, Loew, an apprentice of the skilful Robert Gray, of London, established himself in Philadelphia, and such was his repute that he received the contract to build an organ for St. John's Chapel, in New York, in preference to any New York house. This was the organ captured on its passage to New York in the war of 1812, by an English frigate, and afterwards redeemed for $2,000. Mr. Loew having died in the meantime, the organ was put up by Thomas Hall, one of his apprentices, who afterwards settled in New York and became renowned in the trade.

The organ exhibited by E. and G. G. Hook and Hastings stood in the gallery at the eastern end of the Main Building, its resonant tones being, when uninterrupted by the noise of visitors, clearly audible the entire length of nearly 1,900 feet. Nor was it less noteworthy for the pure, rich quality and characteristic individuality of its several well balanced registers. The instrument comprised four manuals, each of 58 notes, 47 speaking stops, 12 mechanical registers, including couplers, 10 pedal movements for combinations, etc., including a crescendo pedal controlling the full power of the organ. Total number of pipes, 2704.

Great Organ—14 Stops.

1. 16 ft. open diapason	Metal, 58	8. 3 ft. twelfth	Metal, 58
2. 8 ft. open diapason	„ 58	9. 2 ft. fifteenth	„ 58
3. 8 ft. doppel-flöte	Wood, 58	10. 3 rank cornet	„ 174
4. 8 ft. gamba	Metal, 58	11. 4 rank mixture	„ 232
5. 6 ft. quinte	„ 58	12. 16 ft. trumpet	„ 58
6. 4 ft. flute harmonique	„ 58	13. 8 ft. trumpet	„ 58
7. 4 ft. octave	„ 58	14. 4 ft. clarion	„ 58

Swell Organ—11 Stops.

15. 16 ft. bourdon	Wood, 58	21. 4 ft. violina	Metal, 58
16. 8 ft. open diapason	Metal, 58	22. 3 rank cornet	„ 174
17. 8 ft. viola	„ 58	23. 8 ft. cornopean	„ 58
18. 8 ft. stopped diapason	Wood, 58	24. 8 ft. oboe	„ 58
19. 8 ft. quintadena	Metal, 58	25. 8 ft. vox humana	„ 58
20. 4 ft. flauto traverso	Wood, 58		

Choir Organ—9 Stops.

26. 8 ft. geigen principal	Metal, 58	30. 4 ft. flute d'amour	Metal, 58
27. 8 ft. dulciana	„ 58	31. 4 ft. fugara	„ 58
28. 8 ft. melodia	Wood, 58	32. 2 ft. Piccolo	„ 58
29. 8 ft. rohr flöte	Wood and Metal, 58	33. 8 ft. clarionet	„ 58
		34. 8 ft. vox angelica	„ 58

Solo Organ—2 Stops.

35. 8 ft. stentorphon	Metal, 58	36. 8 ft. tuba mirabilis	Metal, 58

Pedal.

37. 32 ft. bourdon	Wood, 42	40. 16 ft. trombone	Wood, 42
38. 16 ft. open diapason	„ 42	41. 8 ft. bell gamba	Metal, 42
39. 16 ft. violone	„ 42		

By Coupling.

42. 16 ft. bourdon.
43. 12 ft. quinte.
44. 8 ft. violoncello.
45. 8 ft. octave.
46. 8 ft. trumpet.
47. 4 ft. super octave.

Mechanical Registers.

48. Swell to great, coupler.
49. Choir to great, coupler.
50. Solo to great, coupler.
51. Great organ separation.
52. Choir, sub-octave.
53. Great to pedal, coupler.
54. Swell to pedal, coupler.
55. Choir to pedal, coupler.
56. Solo, to pedal, coupler.
57. Swell to choir, coupler.
58. Tremolo swell.
59. Solo to itself, super octaves.

Pedal Movements.

1. Forte combination pedal for great organ with appropriate pedal stops.
2. Mezzo combination „ „ „ „ „ „
3. Piano combination „ „ „ „ „ „
4. Forte combination „ swell organ „ „ „ „
5. Piano combination „ „ „ „ „ „
6. Forte combination „ choir organ „ „ „ „
7. Piano combination „ „ „ „ „ „
8. Full organ, all stops.
9. Reversible pedal for great and pedal coupler.
10. Crescendo pedal.

All manual couplers connecting with the great key-board were controlled by knobs directly over it, and operated by pneumatic motors applied to each note of the great manual and its couplers, to the pedal in part, and to the registers. All the combination pedals were double-acting, and operated without affecting combinations previously made by the registers. There were three bellows, the two main ones having vertical feeders, supplying 3,600 cubic feet of compressed air per minute. An extra wind-pressure was used for the pedal, all motors, and a portion of the great manual and independent bellows supplying wind, of great pressure, for the stentorphon and tuba mirabilis. Hydraulic motors operated the different bellows placed below the organ on the main floor. The exterior comprised groups of metal and wood pipes, sustained by ornamental bands, above a substantial casing of walnut-wood, the larger metal pipes being grouped at the sides; between them, raised on a light, open arcade, were smaller pipes, behind and above which appeared the tops of the pipes of the solo organ; while above and back of all were seen the tops of the 32 feet bourdon pipes. The organ was 40 feet high, 32 feet wide, and 21 feet deep, and, because of ample space, nothing was crowded. The bellows and sound-boards were properly extended, admitting large scaled pipes, with sufficient speaking room, and easy access to every part for adjustment and inspection. An independent key-board or fourth manual was provided for the powerful tuba and stentorphon stops, as they could thus be made more available for solo use. The marvellous effect of these two stops, singly or combined, was unequaled. Noticeable also were the great power and variety of the pedal stops, the grandeur of the 32 feet contra-bourdon, and the advantages of the octave and quinte couplers applied to each pedal stop separately, so that the octave of any one or more stops might be used without affecting the others. In effect the five pedal stops were increased to eleven, and these were affected in proper order and selection by the grand crescendo and combination pedals, so that the manual stops would always have their complement of pedal stops.

The double-acting combination pedals, in connexion with the pneumatic coupling-knobs, and the grand crescendo pedal, gave a system of great comprehensiveness and easy control, enabling the organist to have complete power over every part of the organ, and to effect all changes without removing his hands from the keys. The parallel feeders of the bellows, operated by water motors, give a steady and full supply of air with but ten or twelve full strokes per minute, for full organ playing. There was an unusually high air-pressure, yet delicacy was obtained for the softer stops, and for the diapasons, a most agreeable, smooth yet lusty tone.

We recall no organ of equal size and power that could be played with so much ease and satisfaction to the organist, or with so much gratification to the listener. The key, stop, and combination action were reduced to the minimum of resistance, and the utmost convenience was considered in the disposition of key-boards, registers, pedals, etc.

Another organ of the first rank was that of Hilborne D. Roosevelt, of New York City, the award to which by the Centennial Commission says, "It is an "instrument of very large dimensions, having three manuals; is of good "materials, and of skilful workmanship, exhibiting thoughtful ingenuity in its "mechanism and construction, and in its grouping of facilities for the player. "Its touch is light under every burden, its tones rich and delicate, yet firmly "pronounced, the voicing—that of the English system, being equable, and not "sacrificing the characteristics of the several registers to the power of the whole. "The yield of sound in full blending is grandly effective. It has a convenient "system of changeable-combination pedals, novel wind-chest, and draw-stop "action; another novelty being its means of producing echo-effects by the ap- "plication of electricity."

The scheme is as follows: Three manuals, compass C C to A^3—58 notes. Pedal compass C C C to F—30 notes.

GREAT ORGAN.

Double melodia	16 feet.	Fifteenth	2 feet.
Open Diapason	8 „	Mixture	5 ranks.
Gamba	8 „	Euphone (free reed)	8 feet.
Dulciana	8 „	Ophicleide	16 „
Doppel-flöte	8 „	Trumpet	8 „
Harmonic flute	4 „	Clarion	4 „
Principal	4 „		

SWELL ORGAN.

Bourdon	16 feet.	Flageolet	2 feet.
Open Diapason	8 „	Cornet	5 ranks.
Salicional	8 „	Cornopean	8 feet.
St. Diapason	8 „	Vox humana	8 „
Wald flöte	4 „	Oboe	8 „
Principal	4 „	Tremulant.	

SOLO ORGAN.

Violin open	8 feet.	Tuba	16 feet.
Concert flute	8 „	Tuba Mirabilis	8 feet.
Doppel flöte	4 „	Tuba clarion	4 feet.

ELECTRIC ECHO ORGAN.

Vox humana	8 feet.	Tremulant.	
St. Diapason	8 „		

ELECTRIC SUSPENDED ORGAN.

Traverse flute - - - - - - - - - - - - - 8 feet.

PEDAL ORGAN.

Contrebass (resultant)	32 feet.	Bourdon	16 feet.
Open Diapason	16 „	Violoncello	8 „
Contrebass	16 „	Trombone	16 „

COUPLERS.

Swell to great.	Swell to pedal.
Solo to great.	Great to pedal.
Solo to great octaves.	Bellows signal.
Solo to great sub-octaves.	Water-engines.
Solo to pedal.	

COMBINATION PEDALS.

Great organ forte, or full organ.	Solo organ forte.
Great organ mezzo.	Piano pedal.
Great organ piano.	Reversible coupler.
Swell organ forte.	Great to pedal.
Swell organ piano.	

Combination Knobs.

Full organ.	Piano organ.
Mezzo organ.	222 small knobs for setting combinations.

The mixture, fifteenth euphone, trumpet 16 feet, trumpet 8 feet, clarion 4 feet, of the great organ, are placed in the swell-box, making a remarkable crescendo effect when used with the swell organ. The instrument was 42 feet wide, 20 feet deep, and 40 feet high, containing great organ, swell, solo organ, pedal organ, electric echo organ, and electric suspended organ. It occupied a central position in the north gallery of the Main Building, and, being exhibited as a specimen of a new American school of organ-building, was intended to illustrate the progress made in the art in this country. Though founded on the best modern European schools, the improvements introduced were for the most part new and American in their origin. The wind-chests were novel in their construction, each pipe having a separate valve, these valves being connected together and to the keys by a combined pneumatic and tubular action not affected by the changes in temperature, or liable to cipher. The combination pedals and knobs were peculiarly novel, being so arranged that the organist can, from the keys, readily change or set a combination on any pedal, from one stop to the full organ. The electric suspended organ was hung directly in front of the gallery, connected to the great organ by a cable of insulated wires, and operated by six cups of the famous Leclanché battery, the electric echo organ being situated in the English tower, and connected to the great organ by a small cable, 250 feet long, the action being operated by a Leclanché battery. The voicing, on which mainly depends the success of the instrument, was deserving of close study and examination by those interested in the subject. The great delicacy and characteristic quality of tone of the different stops, and the immense power, without harshness, of the full organ, were the result of a most careful school of voicing, combining all the best points in European voicing with some effects never before produced.

Another church-organ of very high rank, with two banks of keys, was exhibited by E. F. Walcker and & Co., of Ludwigsburg, Germany, the justly celebrated builders of the great organ in the Boston Music Hall. It stood upon the floor, on the principal passage of the Main Building. Its case was of oak and in Gothic style. Its wind-chests were constructed after the makers newly-invented system of conical valves without springs, the chests by their great solidity resisting every variety of climate. The wind was supplied by three piston-bellows, distributing air with the utmost equality. All the mechanism and the workmanship were faithfully and reliably executed. It was 15 feet from front to rear, not including the key-board, which was separated from the instrument and in its front, covering a space, with the seat, of about 5 by 4 feet, the player facing the audience; about 13 feet wide and 12 feet high at the rear, and 18 feet to the top of the central front, Gothic finish. It contained 19 speaking registers; 16 with 56 pipes each, 3 with 30 pipes each, 3 couplers and 8 composition pedals. The total number of pipes was 1,098, its entire compass being from C C to G,—56 notes, in both great organ and swell organ with C C C to F, two and half octaves of pedals. It was an instrument of the highest excellence, combining power with brilliancy and delicacy of utterance. Its several registers were pronouncedly individual in their characteristics, and the blending of the whole was impressive, solemn, and grand. The materials used were of superior quality and the general workmanship excellent. Its specifications were as follows:

Great Organ (C C to G—56 notes), 728 Pipes.

1.	Bourdon, 16 ft., wood	56 pipes.
2.	Principal (open diapason), 8 ft., pure English tin in the front	56 „
3.	Gedeckt (stopped diapason), 8 ft., wood	56 „
4.	Viola di gamba, 8 ft., proof tin	56 „
5.	Hohl-flöte, 8 ft., wood	56 „
6.	Octave, 4 ft., proof tin	56 „
7.	Rohr-flöte, 4 ft., metal	56 „
8.	Mixture, 2⅔ ft., 4 ranks, proof-tin	224 „
9.	Clarionet, 8 ft., free reeds	56 „
10.	Physharmonika, 8 ft., free reeds	56 „

Swell Organ (C C to G—56 notes), 728 Pipes.

11. Principal, 8 ft., the lowest octave wood, continuation in proof-tin 56 pipes.
12. Lieblich gedeckt, 8 ft., wood - - - - - - 56 „
13. Salicional, 8 ft., the lowest octave wood, continuation in proof-tin 56 „
14. Travers-flöte, 4 ft., overblown, wood - - - - - 56 „
15. Trumpet, 8 ft., reeds - - - - - - - 56 „
16. Physharmonika, 8 ft., free reeds - - - - - — „

Pedal Organ (C C C to F—30 notes), 1,098 Pipes.

17. Sub-bass, 16 ft., wood, stopped - - - - - 30 pipes.
18. Violon-bass, 16 ft., wood, open - - - - - - 30 „
19. Violoncello, 8 ft., wood, open - - - - - - 30 „

Couplers.

20. Swell to great organ (II. man. to I. man.)
21. Swell to pedal organ (II. man. to ped.)
22. Great organ to pedal organ (I. man. to ped.)

Composition Pedals.

23. Tutti (to act full organ).
24. Forte (to act stops Nos. 1 to 8, 11 to 14, and 17 to 19.)
25. Piano (to act stops Nos. 3, 4, 5, 17, and 19).
26. Tutti, II. man. (to act full swell organ).
27. Swell-pedal to II. man. (swell organ).
28. Swell-pedal to physharmonika.
29. Piano-pedal to physharmonika.
30. Tremulant to physharmonika by pedal.

Parlour Organs.

Of these instruments, sometimes called harmoniums or vestry organs, there was an excellent exhibit. They belong to a class of comparatively recent invention, which, growing rapidly into favour, because supplying a want not met by any other instrument of this variety, have assumed a positive commercial importance, and summoned great inventive talent and skill in their manufacture and progressive improvement. Their tones are produced by the passing of air through free reeds, brass tongues being fixed at one end and left free to vibrate at the other on impulse of air, and so yielding musical tones. Their peculiar characteristics are volume, compass, delicacy, and sustained expression, with ease of producing increase or diminution of utterance. The wind is supplied by arrangements controlled by the player, or, as in the larger ones for vestries or small churches, by an assistant at the rear or side. The importance to which the manufacture of reed organs has attained in the United States is attested by the fact that there are about fifty thousand such instruments made yearly in this country by about two hundred and fifty manufacturers. Under the general name of reed-organ are included all instruments played upon by keys like those of the piano-forte, and yielding their tones by the vibration of their reeds.

The first evidence of the manufacture or use of such instruments in America occurs in a patent, granted in 1818, to Aaron Merrill Peasley, for "a new and useful improvement in organs." Messrs. Mason and Hamlin have this patent in their possession. It is so broad in its terms as to show that no instrument of the class could, at the time, have been known to the Patent Office authorities, and so far to warrant the claim that this was an American invention. But instruments are still in existence respecting which it is declared that they were made in Germany previous to the date mentioned. The first instruments of the class were, however, very poor, and no considerable demand for them arose until certain improvements were introduced by two manufacturers in Buffalo, New York, Messrs. Carhart & Needham and Prince & Co., about the year 1850. The former were the first to successfully employ and introduce the exhaust-bellows, now universally employed in these instruments in America. Thus improved, the instrument, under the name of the melodeon, obtained considerable use. About this time Mr. Emmons Hamlin, now of the Mason and Hamblin Organ Co., discovered and developed the

art of voicing reeds, which has proved the most important of the improvements in such instruments, modifying and bettering the qualities of tone obtained from them. It is now employed by all American makers, and is beginning to be used in Europe. The demand for the melodeon increased in proportion to its merits. In 1860, Mason & Hamlin made further improvements in the instrument, using two blow-pedals in place of the one commonly used before, producing a better current of air, and effecting a more even delivery of tone. They also returned to the name of "organ." This form and name were followed by other makers, and soon became universal in America. Meanwhile the force-bellows continued in use in this class of instruments in Europe. It is only recently that the advantages of the exhaust-bellows have been appreciated and employed there. Undoubtedly America now manufactures a greater number of reed-organs than any other country, and the fact that one of our manufacturing concerns has been awarded a first medal at each of the European Expositions at which it has exhibited, and that we export such instruments largely and import very few, would seem to indicate high attainment in this branch of manufacture.

Napoleon Fourneaux made harmoniums (*orgue expressif*) in 1836. They were in box-shaped cases, and the bellows were operated by the foot. They had no stops, each set of reeds having a separate key-board.

Alexandre-François Debain introduced harmoniums with stops and other superior features in 1841. These instruments were so superior to the others named that Debain has always had the credit of being the first to make harmoninms. This is accorded him in the publications referring to the French Exposition of 1867.

The earliest imported harmonium now remembered was seen in the work-room of the late Jonas Chickering, about the year 1836, at his pianoforte factory in Boston. It was imported by him from M. Alexandre & Sons, Paris, who had then attained considerable celebrity. Their house, founded in 1829, for many years supplied the European demand. But the rapid gain of the instruments in public favour allured capital and skill, and now England and Germany are largely engaged in their production and are sending out hundreds of excellent instruments.

The low cost of the generally-used harmonium, its compactness of form, the ease of its management, the generally pleasing nature of its tones (the French call it the *orgue expressif*, or "organ of expression"), and its adaptation to its class of music, the less rapid and difficult, which renders the learning to play upon it a uot very difficult task, all combine to win for it a great deal of favour, and it is rapidly becoming an inmate in musical families whose means may not be equal to obtaining the more costly pianoforte.

Besides the instruments exhibited by Mason & Hamlin,—all of the very first class, excellent specimens were presented by Peloubet, Pelton, & Co., of New York; Taylor & Farley, of Worcester, Massachusetts; the Burdett Organ Co., of Erie, Pennsylvania; the Dominion Organ Co., of Bowmanville, Canada; the Clough & Warren Organ Co., of Detroit, and the Dominion Company of Canada; J. Scheidmeyer, of Stuttgart, Würtemberg (not for award), and G. L. Bauer, of London. All these were of excellent, even, and expressive quality of tone, well-voiced, resonant yet pure, and with much variety in combination.

So far as is known, Mr. Peloubet, of the firm above named, was the first to apply the equal temperament in tuning the reeds, and in enlarging to three banks of keys. In addition to the above names, but not in competition, we find, engaged in the trade, S. D. & H. W. Smith, of Boston; Estey & Co., of Brattleborough, Vermont; G. A. Prince, of Buffalo, New York, and Carhart and Needham, of New York; the latter introducing several new and valuable improvements. They were the first to carry the bass down to thirty-two feet C, and to introduce the exhaust-bellows now in general and approved use. The Prescott Brothers, of Concord, New Hampshire, now the oldest firm in the country; M. O. Nichols, of Syracuse, New York; Peter J. Jewett, of Granby, Connecticut (1833); Jewett, of Worcester, Massachusetts (1837); Swan, of Cherry Valley, New Hampshire (1839); Packard, of Bridgewater, Massachusetts, and Phelps and Goodman, of Syracuse, New York (1850), were pioneers and followers in the trade, and should be commended for persevering efforts at improvement.

Violins.

Of the class of musical instruments to which these belong there was a very full and satisfactory exhibit, many of them being of American manufacture, and some the product of machinery especially invented.

The low price at which very good instruments of this class may be bought was noticeable, as was the fact that cheapness in this case did not always imply inferiority. The violin has remained with very slight, if any, changes for nearly two and a half centuries, the kind of wood used and the models remaining substantially the same as those of the days of illustrious makers, Stradivarius, Amati, Guarnerius, and Albani. There were two violins made by Emmons Hamlin, of the firm of Mason and Hamlin, of Boston, of marked excellence and with much of the characteristic quality of those of the old makers of two centuries ago. Admirable exhibits were also made by the Alberts, and Neff, of Philadelphia; by Subenhühner, of New York; and Glasel, of Germany. Gemunder, of New York, presented a contra-basso of first-rate make, and of rarely excellent qualities in every respect. John F. Stratton of Leipsic and New York, manufacturing for the trade, exhibited an extensive collection of stringed, wood, and brass instruments of good workmanship and cheap in price, many of which, at the same time, were of good quality and excellent tone.

The manufacture of these instruments in the United States can hardly be said to have a history. Few persons have adopted the trade as a speciality, and fewer, if any, have met with encouraging success. Among the few names which we have heard associated therewith are Benjamin Crehore who, in 1785, manufactured violoncellos at Milton, Massachusetts, and who afterwards became a maker of pianofortes, and Samuel Long, of Hanover, New Hampshire, who, about 1812–20, without previous instruction in the art, and with no aid from machinery, made excellent instruments, using old and well-seasoned stock. Abraham Prescott, of Concord, New Hampshire, 1825–35, was engaged in the same line, in making violoncellos and contra-bassos. He afterwards, with a brother, went into the manufacture of melodeons. As a rule, among these early makers, some errors in their proportions weakened sonority and general effect. To remedy this difficulty, and to eradicate the prejudice against instruments of fresh make, is not easy, yet both will be accomplished as experience ripens skill. The introduction of instruments made from carefully selected old wood, and constructed with due regard to the proper adjustment of the parts, will go far in that direction. Such instruments will require but very little time to bring them into extensive use. The application of machinery in the manufacture of stringed instruments will probably be limited to the mere roughing out of the breast and back. After that must come artistic skill and delicate exactness of finish, and these are now directed by the most thoughtful and ingenious manufacturers towards the permanent improvement of the quality of the instrument. Among names also worthy of mention are Warren A. White, of Boston, who obtained considerable reputation and a large demand because of his skill and the general good character of his instruments. Mr. John White, also of Boston, was a successful manufacturer, the top of one of his instruments being, it is said, made from wood of an old organ presented to the town of Cambridge in 1767, and the back and hoops from the communion table of the old church at Lexington, Massachusetts.

Other names of note are George Gemunder, of New York, and Calvin Baker, of Weymouth, Massachusetts. Both have produced fine instruments. Yet the enormous influx of foreign products in this line, many made to sell, of poor, unseasoned stock, with small regard to truth of adjustments, puts our own makers at serious disadvantage, not only because of competition, but because players, as is above hinted, have always strong prejudices in favour of old, time-seasoned instruments.

Band Instruments.

Of the history of the manufacture of orchestral and band instruments in the United States little that is satisfactory or reliable is known. The first maker of band instruments in New England was probably Samuel Graves, at Winchester, New Hampshire, who subsequently established himself in Boston,

and now resides at the former place. Henry Sibley, early in the century, and afterwards E. G. Wright, a man of much skill, worked in Boston, and later, Allen, Fisk, Hall, and Hall and Quimby, all excellent in their art. Many years since, there appears to have been in New York a Mr. Torenzi, probably an Italian, who made, first in this country, ophicleides and kindred instruments. The trade itself may be dated as having its inception in the United States about the year 1825. It is now very widely diffused, and its products rival those of European makers. Among the prominent and successful manufacturers is a firm established in Boston in 1840 by J. L. Allen, succeeded in 1861 by Hall and Quimby, which, continuing to 1875, became the firm of Quimby and Brothers. This now well-known house, by its thorough workmanship and the excellence of its instruments in material, finish, and tone, has attained just celebrity, supplying every variety demanded by bands of the best character. Other manufacturers in good repute are George McFadden, of Syracuse, New York; Conn and Dupont, of Elkhart, Indiana; and Isaac Fiske, of Worcester, Massachusetts.

In this department there was a profuse as well as most admirable display by both foreign and native makers, all classes of the exhibits manifesting valuable novelties for production of better effects, exquisite accuracy, beauty of finish, and thoroughly good workmanship in every particular. Careful and scientific grading of the wind-passages had been secured, producing excellent quality, purity, and truthfulness of tone; an exact and happy arrangement of keys insured facility in fingering; while the quiet working of these keys, and the power and far-reaching capabilities of the several instruments, all testified to the successful appliance of scientific thought, inventive skill, and accurate handiwork. Those who remember the instruments of half a century ago, with their many and acknowledged defects, are at once surprised and gratified at the results achieved by later efforts and inventions in this field of musical art, demonstrating, as they do, the application of correct acoustic principles and accurate construction. For the brass instruments of the older bands, the trumpets, trombones, and horns, and for the serpents, bassoons, and other instruments, more or less deficient in ease of manipulation and in general tonal effect, we have admirable substitutes in great variety, with keys, pistons, and general improvements of a greatly varied character, upon which more difficult and more satisfactory music, more effective as well as more scientific in its composition, is played with comparatively easy execution, even with less persistent practice than was demanded by the less varied and now less used instruments of the older date. Nor is there any loss of purity in the harmonies or in the resonance of the newer ones, for they possess a justness in intonation and a degree of freedom such as even experts found it difficult to attain on the mere harmonic instruments of the old school.

It is not certain who originated the system of valves, but about the year 1825 valve instruments were used by order of the Emperor of Russia in a band of one of the regiments of Life Guards. It is claimed that a Mr. Adams, of Lowell, Massachusetts, invented them, applying three of them to a horn, which he took with him on board a United States ship-of-war on a cruise up the Mediterranean. When in a French port the novelty attracted notice, was at once adopted by manufacturers abroad, and the credit of the invention departed from us.

We have then horns, trumpets, trombones, and cornets constructed on scientific principles, and possessing greater power, more impressive resonance, and greatly attractive richness of tone. Of these qualities the sax-horns, invented by Adolphe Sax, of Paris, are notable examples.

In fact, there has taken place within the century an almost total revolution in the instruments of military bands, of which the saxophones—instruments with reeds like those of a clarionet—may be taken as an example of striking originality in tone, and greatly contributing to musical expression in both band and orchestra.

Among the exhibitors of the best of these instruments in brass may be classed Besson, of London; Mahillon, of Brussels (author of an admirable treatise on wind instruments); Farsky and the Fuchs, of Austria; Alberg and Ohison, of Sweden; the "Boston Musical Instrument Manufactory," of Boston; and H. G. Lehnert, of Philadelphia. A similar improvement was

noticeable in several pulsatile instruments; the drums, though reduced in size, were increased in resonance and far-reaching sonority, and the cymbals, &c., were of reduced dimensions, more easy manipulation, and lighter, yet with no loss at all in power and effect. Similar praise may be bestowed upon the guitars and the zitherns, as well as for their much better finish; even the banjo having received careful attention, and consequent improvement in workmanship and in tone.

Of the smaller musical instruments, the guitars, zitherns, accordions, concertinas, mouth-harmonicas, tambourines, and banjos, there was quite a large exhibit by various manufacturers, and of much excellence in their kind. The zithern (cithara) is hardly known here or in England, but is much used on the Continent. It is a species of guitar with added strings for re-enforcing the harmony. Like the guitar in Spain, it is used to accompany the voice in singing.

Automatic Musical Instruments.

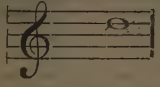
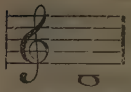
Quite a number of self-acting instruments, known as orchestrions, were on exhibition, some of large size, with ingenious and elaborate mechanism. These are intended to supply, in the compass of a single instrument, the effect of a full orchestra, or a full band, and are chiefly used in exhibitions like those of a museum or of a travelling circus show. Though not yeilding the most delicate or refined music, theirs being generally of a very full and pronounced character, they are well adapted to the field for which they are intended. Yet several of them were specimens of very skilful workmanship and most ingenious mechanism. Such were the orchestrions of Welte and Sons, of Germany, and Gavioli and Co., of Paris. Such also were the several music-boxes in the Swiss department, some of them being of extraordinary size, capabilities and effects, and yielding music of a most pleasing character. Those exhibited by Messrs. Paillard and Co., St. Croix, Switzerland, were among the very best of their kind, having much novel and ingenious mechanism, giving clear, resonant, and pleasing tones, quite orchestral in their effects. Other excellent and praiseworthy instruments of this class, very attractive for their ingenuity and musical effect, were presented by Bremond, Karrer, and Adank, all of Switzerland, where the manufacture of this class has long been a successful speciality. In both workmanship and tonal results they were all admirable.

Musical Accessories.

The many excellent exhibits of various accessories to musical instruments were entitled to great commendation. These were felt cloths for pianofortes by Dolge; piano leathers by Schlesinger and Lammer and the Geyers, of Germany; reeds for parlour-organs by the Ingalls Reed Company, and the Monroe Reed Company, of Massachusetts; the double sounding-boards by Koch, of St. Petersburg; the violin strings by Mueller, of Saxony, and Stratton, of Leipsic and New York; the strings of Grandjon, of Paris, for all varieties of bowed instruments, also his bows, bridges, keys, cases, and other accessories of various kinds; the pianoforte wire by Poehlman, of Nuremberg, of remarkable tensile strength, and of Washburn and Moen, of Worcester, Massachusetts, of beautiful and even finish; the organ-pipes of Zimmerman, of Paris, of admirable workmanship in every respect; and woods for sounding-boards, ivory keys, &c., by several exhibitors, native and foreign, all of great general excellence, and entitled to much credit.

Bells.

In 1736 a foundry for casting large bells was established at New Haven, Connecticut, by Abel Paombe, who, in his petition to the General Court of the State, declares that his was the first attempt made in the colonies. Another earlier casting of bells was by Mr. Hanks, in Mansfield, Connecticut, at a place called Hanks' Hill. He also, at the time of the Revolution, cast bronze cannon for the American army. About the same time, Aaron Hobart, at Abington, Massachusetts, engaged in the same work of casting bells, cannon, and shot. At Stoughton, in the same State, a bell foundry was established in 1770. The celebrated Paul Revere, of Revolutionary fame, cast bells in Boston prior to 1790. But it is to be noted that, in these earlier efforts, the casting of bells

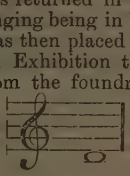
was connected with other miscellaneous casting, not appearing to have been made a specialty, as is now the case in many establishments, where experience and skill have reached such a point that one may be sure his order will be answered with entire exactness and accuracy of tone, whether it be for a small bell of 400 pounds on  or a large one of 6000 pounds on 

Among well known houses in Boston was that of Henry N. Hooper, who died in 1865, after establishing an extensive business and gaining high repute. He was succeeded by William Blake, who was for some years associated with Mr. Hooper, the firm being now that of William Blake & Son. Mr. Blake, beginning the business in 1820, died in 1871, being one of the oldest in the trade. The bells of this firm bear a deservedly high rank.

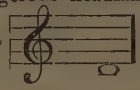
Among other noted bell-founders are Holbrook, of Medway, Massachusetts, dating from 1825, the establishment being still continued by his successors; Meneely & Kimberly, of Troy, New York; Vanduzen & Tift, of Cincinnati; McShane, of Baltimore; and Meneely & Co., of Troy, New York. This latter firm dates from 1826, when it was established by Andrew Meneely, the name continuing in the firm to the present time. Their bells bear a very high reputation, being cast from rigid formulæ, and securing the desired tones with uniformity and success. Indeed, no firm can succeed in this business except by persistently following precise mathematical rules, and using the most perfect mechanical appliances. In exact ratio to compliance with these laws and these means will be the success of any foundry. Of chimes and peals alone the Meneely firm have cast, since 1840, nearly one hundred.

The earlier bells in America were all imported, those of Quebec being probably the earliest, and used in the Catholic churches and convents. From thence their use spread wherever the Catholic missionaries carried the gospel. Every little chapel they erected in the wilderness, and wherein they preached to the Indians, had its bell to summon the red men to mass. There is one of them in the museum of Bowdoin College, in Maine, which belonged to the chapel of Father Ralle, killed by the Indians in 1724, at Norridgewock, Maine.

The Independence Bell was cast in England in 1752, broken, and recast under direction of Isaac Morris, by Pass & Stow, and placed upon Independence Hall. Removed to Lancaster on occupation of Philadelphia by the British in 1777, it was returned in due time, being afterwards used on state occasions, the last ringing being in honour of the visit of Henry Clay, in 1828, when it broke. It was then placed in the Hall, where it yet remains.

At the Centennial Exhibition there were excellent exhibits of bells, one being a full chime from the foundry of Henry McShane & Co., of Baltimore, of thirteen bells from  upwards. These were mounted in a tower at the eastern end of Machinery Hall, and played every day. They were of clear and good tone, and with quite correct overtones, considering that they were set up immediately after casting with no especial tuning. Schmidt's rotary yoke, used with these bells, gives the great advantage of permitting a bell to be turned from time to time, as exigency may demand, so that the blow of the hammer may not always strike on the same part, and so, by continued impact, weaken the point and endanger cracking.

Two other bells, one cast by the brothers De Poli, of Italy, and the other by Hadank & Son, of Germany, attracted particular notice because of their excellence in casting, elaborate ornamentation, volume and purity of tone, and well defined and correct harmonies. Another exhibit of bells in the Main Building, about a dozen in number, of various sizes, weights, and tones, was made by Messrs. Vanduzen & Tift, of Cincinnati, Ohio, all of which were of first-rate workmanship and material, accurate in tones and overtones, clear in resonance, and highly creditable to the manufacturers.

A large bell of some 3,500 pounds in weight, by William Blake & Son, Boston, Massachusetts, intended as a fog bell, with automatic apparatus for tolling, and to be placed on some dangerous headland, was on exhibition near the Government Building. It was a  bell, admirably cast, with great accuracy in overtones, and of clear and far reaching resonance.

Hand-, house-, and sleigh-bells, of great variety and of excellent quality and resonance, were exhibited in the Main Building by the Bell and Gong Manufacturing Company, of East Hampton, Connecticut.

The fog horn of Brooks, of Boston, operated by blasts of steam, made a lasting impression at the Exhibition. It was a most successful noise maker, heard easily by residents a dozen miles distant, and was reputed to have a sound carrying power of thirty miles, giving ample warning to vessels nearing dangerous points upon sea coasts. For this purpose it is admirably adapted.

Musical Typography.

In this department of the music trade, those who remember the feeble and imperfect efforts, and the ordinary, cheap, and coarse work turned out during the last quarter of the eighteenth and first quarter of the nineteenth centuries, both in Europe and in the United States, will doubtless readily testify to the almost incredible improvement which has followed, and which seems to be rapidly attaining perfection. The art commenced in the fifteenth century with engraved fragments on wood for missals and for some few educational works. But musical typography, rigidly so called, by means of movable types of metal, was not invented till near the beginning of the sixteenth century, when Octavien Perucci, of Fossombone, in Italy, produced some specimens from his presses. He was early quite successful, and his example was followed by printers in Italy, France, and Germany. England took it up, and has now attained eminent success, in producing, at cheap cost and in most convenient form, a vast quantity of the works of the best composers, the publications by the house of Novello & Ewer, of London, leading, whose agency in this country is with J. L. Peters & Co., of New York, who also issue works in the highest excellence of the art. Oliver Ditson & Co., of Boston, are likewise among the leading publishers, and issue an immense amount of music in commendable style, providing for the wants of both the beginner and the expert. Among other extensive publishers are G. D. Russell, of Boston; Pond & Hall, in New York; Church & Co., and the Brainards, in Cincinnati; André, and Louis Meyer, in Philadelphia, and very many others, representing a business in which more than three millions of dollars are invested. At the Exhibition very many and attractive specimens were shown.

HOROLOGICAL INSTRUMENTS.

By James C. Watson.

The exhibits were not equally complete in all the departments of horology, but still they were from all countries which have any considerable manufacture in the way of horological instruments, and the productions of some of the most famous manufacturers were represented. The number of clocks exhibited was not very great, but some of them were remarkable for novelty of construction or for exquisite workmanship. The number of marine chronometers was considerable, including the productions of the best American, English, Swiss, French, and Dutch makers. The display of pocket chronometers and watches was very large, and their examination occupied a very considerable portion of time of the Judges. For the first time the products of our American manufacturers were exhibited at an International Exhibition. The best English, French, and German makers exhibited numerous specimens of their work, while the Swiss made a display in number and variety sufficient to indicate to even an uninformed observer the extent and the perfection of this industry in their country. Besides these, there were exhibited various other horological instruments, which will be mentioned in the course of this report.

Instead of describing the various productions of single exhibitors under one head, it will be better to bring together the productions in a single class, and

hence often it will happen that the full knowledge of what was exhibited by a single manufacturer can only be obtained by consulting this report as a whole. In accordance with this scheme, various forms of clocks will first be considered, commencing with turret clocks, then marine chronometers, and, finally, pocket chronometers, watches, and miscellaneous horological instruments.

I. Turret Clocks.

It is scarcely more than a quarter of a century since it was considered possible to construct a turret clock with any considerable pretensions to accuracy as a time keeper. The unstable character of the mounting, the changes of climate, the violence of storms acting upon the exposed pointers of the dial, and hence upon the train, and the mechanical difficulties arising from the great size and weight of the parts, were such as to make it appear futile to construct such a clock with the care which would be expended upon one for accurate time keeping. The invention of various forms of isodynamic escapements, simple to execute and reasonably certain in their continued action, made it possible to use a train less highly finished, and hence to construct even tower clocks with a degree of perfection hitherto unattainable. The number of such clocks annually constructed is considerable; but, notwithstanding the importance of the industry in this particular branch, there were only a few tower clocks on exhibition, and these we proceed to describe.

Seth Thomas Clock Company, Thomaston, Conn.

In Machinery Hall, in actual operation in the tower, was a large turret clock, solidly constructed and finished in excellent manner throughout. The wheels were of gun-metal, and carefully finished, so as to secure the theoretical requirements for smooth action of the train. There is nothing new in connection with this clock which requires description, and the award which was made was on account of excellence of workmanship in its manufacture and intelligent application of theory in its design. The escapement is that known as Dennison's double three-legged gravity escapement, the execution of which has been effected with the very best workmanship possible. Hence, as might be expected, the action of the escapement was found to be excellent. The driving weight weighs 200 pounds. The pendulum is zinc and steel compensation. The weight of the pendulum rod is 200 pounds, and of the pendulum ball 500 pounds. The great weight of the whole pendulum, 700 pounds, requires that provision be made against injury resulting from the accidental breaking of the pendulum-spring, and such protection was duly provided. The exhibitors stated that repeated trials have never shown any case of tripping in the action of the escapement, and that considerable changes of weight applied to the train did not sensibly change the arc of vibration of the pendulum. A careful inspection of the parts showed that great care had been taken not only in the finishing of the acting surfaces of the escapement, but also in the exact adjustment of their positions as required by theory, so that it is reasonably certain that, undisturbed, this clock will perform its functions with great precision, while, under the vicissitudes to which it may be subjected, its performance will be as perfect as can be secured by this approved form of construction.

Charles Fasoldt, Albany, N.Y.

This clock, exhibited in the Main Building of the Exhibition, was constructed upon a new plan, invented by Mr. Fasoldt, and successfully carried out in a number of tower clocks constructed by him, and showed great excellence of performance in actual use. The essential idea of Mr. Fasoldt's construction is to employ an accurate clock, of moderate dimensions, to control the motion of a turret clock in connexion. It would, of course, be immaterial, so far as relates to the clock controlled, what the form of construction of the controlling clock might be; but Mr. Fasoldt's merit is to be considered in this case in reference to both parts. We shall, therefore, consider first the construction of the controlling clock, which may be used as well for a standard time-keeper, independently of its adaptability for the purpose of controlling a turret clock in connexion.

The principal novelty in the construction of this clock is in the escapement, the arrangement of which is the invention of Mr. Fasoldt. It is of the class

known as gravity escapements, the impulses to the pendulum being given by a gravity arm or lever whose oscillations are created by the escapement. There are in reality two scapewheels, one for locking and unlocking, the other for communicating the proper motion to the gravity-arm for the impulse of the pendulum. There is upon the arbour of the impulse escapement-wheel a toothed wheel, which gears into a pinion on an arbour which carries a sectional or locking-wheel. This wheel has a suitable number of projecting arms, which may be two, four, six, or more, as may be required. The arms of this sectional wheel are arrested by the pallets, which are jewelled, and so inclined as to give the minimum of friction in unlocking. One of the locking-pallets is slowly unlocked, being near the axis; the other quickly, being farther from the axis. To the supporting frame of the clock is pivoted a lever the upper end of which is connected with the pendulum by means of the crutch, while the other extremity carries an unlocking piece which is moved by the motion of the pendulum alternately over the inclined inner faces of the fork attached to the escapement-lever. Suppose now that the sectional scape-wheel, symmetrical with respect to its axis, has at each extremity two projecting arms. Every vibration of the lever connected with the crutch will produce, by its contact with the fork, a vibration of the escapement-lever, and every other vibration of this lever will bring another arm of the section-wheel in contact with it. Thus, if the sectional locking-wheel has but one arm with two detents at the end, it will make one rotation at every back and forward motion, and impart one impulse to the pendulum through the gravity-arm. By four detents on one or each arm one impulse is imparted to the gravity-arm, the same having made four oscillations; by six detents six oscillations and one impulse, &c. The motion of this wheel is so related to that of the impulse escapement-wheel that the latter is moved the space of one tooth during each rotation of the former, or part of rotation, as the case may be.

To a projecting arm of the crutch-lever is pivoted a gravity-lever whose lower end is suspended directly over the impulse-wheel, and at whose upper end is an arm carrying an adjustable weight. Whenever the impulse-wheel is turned one of its teeth bears against the lower end of this gravity-lever, and moves it along, thereby giving the requisite impulse to the pendulum. After the tooth of the impulse-wheel has carried the gravity-lever to the end of the impulse this lever remains in that position until drawn out by the oscillation of the pendulum; then it drops upon a resting-pin, projecting from the crutch-lever, into a neutral position, and it is, in such position carried clear of the teeth of the impulse-wheel during the return vibration. As soon as the crutch-lever commences to swing in the opposite direction the gravity-lever will be at once acted upon by the next tooth of the impulse-wheel, and so on. The motion of the scape-wheel is so regulated that the locking and unlocking of the pallets is always secure, and error from tripping entirely avoided. The records of the performance of clocks with this escapement show excellent results.

By a suitable device for the suspension of the pendulum the gravity-lever may be attached directly so as to obviate the necessity for the use of a crutch, thus simplifying the movement somewhat. The clock exhibited has a pendulum with mercurial compensation, and an adjustment of the faces which hold the pendulum springs so as to compensate for unadjusted circular and escapement errors.

When applied to turret clocks no modification of the movement just described is necessary. Its functions are performed in entire independence of the connexion with the turret machinery, although so connected that the motion of the latter is under its control. Its regular motion is not, therefore, interrupted by any irregularities in the movements of the hands upon the great dials, produced either by the influences of the weather or other causes, and the correct time may be indicated on any required number of dials without correspondingly enlarging the size and power of the clock mechanism. Power is imparted to the clock-train and to the hand-driving mechanism by separate weights.

To the main arbour of the clock-train is attached an unlocking-wheel, which has a greater or smaller number of teeth, according as the forward motion of the minute hands upon the great dials is intended to be performed in greater or smaller intervals of time; for example, at every half or whole minute, or

otherwise. The teeth of this unlocking-wheel engage a V-shaped fork that is firmly applied to a separate arbour of the clock-train, and raised by one tooth after the other as the wheel rotates, to be dropped when carried up till the contact of the tooth and the upper arm of the fork is discontinued. To the outer end of this arbour is attached an arm, with projecting rest or guard-plates at one or both ends, that follow accurately the motion of the arbour by being alternately raised and dropped therewith. The control of the hand-driving mechanism is now effected in this manner. The guards or rests just mentioned serve to arrest and release the end of a balanced spring-arm, which is keyed to the shaft of a small revolving pinion, which meshes with a toothed wheel of large but accurately-proportioned size applied in a fixed position to the clock frame. The shaft of the revolving pinion is supported in bearings of a frame keyed to the end of the arbour, passing through the centre of the large fixed wheel, and accurately balanced by being weighted at the diametrically-extended arm of the same, so that the swinging of the frame and the complete revolution of the pinion around the circumference of the fixed wheel are accomplished with the desired perfection of motion. This motion of the pinion and balance-frame around the fixed wheel forms the intermediate locking and liberating mechanism of the clock-train and hand-driving power.

The gradual raising of the fork to the unlocking-wheel of the main arbour of the clock-train raises the guard-lever on the rests of which the spring-arm of the pinion lies, until, at a point near the highest limit of motion of this lever, the spring-arm is released, and transferred to the guard-plate at the opposite lower end of the lever. The dropping of the fork to the next tooth at the moment of arriving at its highest point carries the lower guard-plate rapidly in an upward direction, which motion liberates the spring-arm, and produces by the action of the turret power the complete motion of the revolving pinion and the spring-arm, until the latter is again arrested by the stops of the guard-lever.

The arbour to which the revolving frame is attached communicates by a pinion with an intermeshing wheel, attached to the main arbour of the turret-weight. This gears again, by an outer bevel-wheel, with a bevel-wheel attached to the vertical shaft for transmitting the motion to any height in the tower. Simultaneously with the revolution of the pinion the arbour of the hand-driving weight, being free to move, transmits motion to the vertical shaft and to the hands, so that they are moved forward the proper distance on the dials. Any interruption of the regular motion of the hands by ice or snow, or by the breaking or injury of one of the intermediate parts, arrests only the regular working of the hand mechanism, without affecting in the least the clock-train. This continues its regular course, and thus is secured for the clock a freedom from repairs and supervision, and a reliability and accuracy of performance, which could not be obtained by the direct working of the dials from the clock-train in the usual manner.

The great dials for indicating the time may be placed at any distance above or below the clock train and turret clock mechanism, and hence it may occur that on account of the length of the vertical shaft a considerable weight will have to be overcome. This is accomplished by suspending the shaft from a carriage that revolves on a platform at the height of the centre of the dials. If the time is to be indicated on another set of dials below the clock, as is found very useful in many cases, either a separate shaft is suspended in connexion with the main arbour of the hand-driving machinery, and operated thereby, or an extension of the same shaft, supported by another carriage and platform, is provided to facilitate the transmission of motion to the lower dial hands. Bevel wheels at the extremity of the vertical shaft transmit finally the motion to the minute hand, and in the usual manner this controls also the hour hand. There is also provision made by which the hands of the great dials may be easily set to correspond with those of the controlling clock whenever, on account of the temporary derangement of the turret machinery, or from other causes, it may become necessary to do so.

The greater the number of hands and dials employed for indicating the hour at various heights of the tower, or in various stories of a building, the greater in proportion has to be the power of this part of the machinery, while the size of the clock-train is not increased; so that the latter may be constructed with all possible delicacy and in a compact form; and besides, it may be put up at any convenient part of a building or tower.

The accounts rendered of the performance of some of these clocks in actual use are very satisfactory; and, besides, the convenience of the arrangement, as well as the relative cheapness at which they are constructed, are positive recommendations in their favour.

Hadank and Son, Hoyerswerda, Germany.

A tower clock and bell. The clock was in compact form and of good workmanship throughout. It has the ordinary dead-beat escapement, and hence, considering the difficulties to be encountered in the case of clocks of this size, it cannot be expected to perform as well as those which have already been described. The bell is of excellent composition, and the casting apparently perfect.

Louis H. Spellier, Doylestown, Pa.

A large clock with four dials, which was well made. It had lantern pinions and the ordinary form of pin-wheel dead escapement. The pendulum, with mercurial compensation, was suspended by two springs which passed over friction rollers, the object of the arrangement being to bring the pendulum back speedily to its proper plane of vibration in case of any disturbance. This is too complicated, and, besides, it introduces sources of error too considerable to be neglected. It is not therefore to be recommended; but the workmanship throughout was considered worthy of commendation.

II. Astronomical Clocks.

The number of first-class astronomical clocks exhibited was small, but there were nevertheless some specimens of excellent workmanship. Those exhibited were of the ordinary form, with Graham's escapement, and with mercurial or zinc and steel compensation.

A. Hohwü, Amsterdam, Holland.

This pupil of the celebrated Kessels exhibited an astronomical clock of excellent workmanskip throughout. The clocks by this maker have shown the best results when subjected to actual trials in an astronomical observatory. One of them has been in use for several years in the observatory at Leyden, and has received the highest commendation from the officers of that observatory. Those who are acquainted with the performance of standard clocks in astronomical observatories, where accurate time-keeping is of the first importance, will understand better than the generality of clockmakers even what may be expected in reference to the performance of such instruments. The theoretical method of construction being well established, the choice of a clock must depend upon the skill of the maker in producing that delicate and accurate workmanship which is necessary in order to reduce the errors of its performance to a minimum.

In the discussion of the observations made at Leyden, the clock under consideration, Hohwü No. 17, was not disturbed in any way, except from climatic changes, for a period of two years and a half, and during this interval its temperature was subject to a considerable range. The mean daily rate at the beginning and end of this period differed only a few hundredths of a second. It was found that its daily rate could be computed almost exactly by the following formula:

$$\text{Daily rate} = -0{\cdot}339^{s} + 0{\cdot}0174^{s}\,(10^{o} - t) - 0{\cdot}011^{s}\,(760^{mm} - b),$$

in which t denotes the reading of the thermometer in degrees of Réaumur's scale, and b that of the barometer expressed in millimetres. Subsequently, after the lapse of a considerable interval of time, a second series of observations was made, extending through twenty-eight months, the discussion of which gave the following formula for the daily rate:

$$\text{Daily rate} = -0{\cdot}339^{s} + 0{\cdot}01885^{s}\,(10^{o} - t) - 0{\cdot}01269^{s}\,(760^{mm} - b).$$

The comparison of this result with that obtained from the first series shows that the co-efficients which express the effect of heat and atmospheric pressure upon the rate of the clock had changed slightly, while the normal rate for the temperature, 10° Réaumur, and the barometer at 760 millimetres, had remained unchanged. This seems to prove conclusively that the normal rate of this clock

was not affected by the climate changes to which it was subjected. Other clocks by the same maker, subjected to rigorous trials, have given similar results. The co-efficients for temperature were always very small, and of course different for the different clocks, but the barometric co-efficients showed in every case a remarkable agreement.

Charles Frodsham and Co., London, England.

Several fine clocks, one of which had a pendulum vibrating every two seconds. These clocks were finished in the manner characteristic of their work, the excellence of which has given them a world-wide reputation. There are many of their astronomical clocks in use in observatories in different parts of the world, and, although the reporter has not at hand any elaborate discussion of observations to indicate their running qualities, it is at least certain that the results have been wholly satisfactory.

John Linderoth, Stockholm, Sweden.

A fine clock, with Graham's escapement and mercurial compensation, the finish of which was of a high order. Mr. Linderoth is considered to be the most skilful maker of clocks in Sweden, and, so far as could be determined without an actual trial, the clock exhibited clearly enough attested his skill.

Gustav Becker, Freiberg, Silesia, Germany.

An astronomical clock with zinc and steel compensation, in a mahogany case with marble base, the price of which was quite reasonable for a clock so well constructed. The style and finish were quite like clocks by Tiede, of Berlin, which the reporter has seen.

John L. Gropengeisser, Philadelphia, Pa.

A clock constructed by himself. It had lantern pinions, and the pallets were in the pendulum-rod itself, thus obviating the necessity of anchor-pivots. There is nothing in the way of novelty in this construction. The workmanship was of a high order, but it was impossible to determine the character of this clock as an instrument of precision without an actual trial such as could not be made during the Exhibition.

III. Regulators and Clocks for Commerce.

There is a class of clocks constructed in accordance with approved methods, and with approved forms of escapements, which are often quite well finished, and which are supplied with pendulums in a greater or less degree compensated for changes of temperature. They are intended for use in counting-houses, railway-offices, and other places where accurate time-keeping is desired, but not in the sense in which it is applied in the case of astronomical observatories for the purposes of astronomical observations. Such clocks are those, too, which most of the jewellers and watch-repairers use as standard time-keepers, and hence they are known as regulators. There are many such in use which ill deserve any such appellation. Very often there is no real attempt to compensate for temperature. It is true that the pendulum-rod is made of alternate rods of brass and steel, for the sake of show, and in imitation of the gridiron pendulum, but there is no actual provision for compensation, and, so far as the time-keeping properties are concerned, it would have been vastly better if the pendulum-rod had been made of wood, and, if necessary in order to disguise the character of the clock, concealed by a closed case. The reporter has seen many clocks with good movements, dead escapements well finished and duly adjusted, and even jewelled holes for the anchor-pivots, which had this mock compensation. As might be expected, among the clocks of this class at the International Exhibition there were all grades to be found, from those which were almost sufficiently well constructed to be used as instruments of precision to those which could scarcely rank with some of the specimens of clocks of commerce for ordinary use. It is not necessary to consider them separately, whatever the excellence or defects of their construction, since they were exhibited with other clocks of inferior grades by the same makers, and hence they are here classed under a common head with the clocks of commerce.

American Clocks.

The manufacture of clocks in the United States has become a distinctive branch of our industries. The use of stamps to cut from plates of brass the frame and the wheels of the train, as well as other parts, and the use of lantern pinions, the whole made with cutters which are of proper form, has enabled our clock-makers to produce what are known as American brass clocks, of a quality sufficient for the ordinary purposes of house clocks, and at price so low as to open for them a market in every country of the globe. Numerous specimens of this manufacture were shown at the Exhibition. Among those whose productions were shown were the Seth Thomas Clock Company, of Thomaston, Connecticut; E. M. Welch & Co., of Forestville, Connecticut; the New Haven Clock Company, of New Haven, Connecticut; and the Ansonia Brass and Copper Company, of Ansonia, Connecticut. These clocks were of every style and size, from a regulator with seconds pendulum to a small marine clock with lever escapement, and power communicated to the train by a spring. The parts of the movements of many of them were nickel-plated. The majority of them had striking attachments, and often, too, there were calendar attachments. These clocks are constructed upon a uniform plan, with interchangeable parts made by machinery, and the rivalry of the manufacturers is almost wholly in the direction of cheapness of production. This has indeed reached a point which, considering the relative qualities of the various productions, leaves scarcely anything to be desired. In addition to good trains for movements to be sold at so low a price, these clocks were placed in well-finished, durable cases.

The Ithaca Calendar Clock Company, Ithaca, N. Y.

A great variety of calendar clocks. The clock movements are constructed for them in accordance with their patterns by E. N. Welch, at Forestville, Connecticut, and their work consists in the attachment and adjustment of the calendar indicator. The parts of the clock movement are cut out of unusually thick sheets of brass, and all the main holes are bushed. The escapements are all dead-beat, whatever the grade of the clock, and the parts are all interchangeable for the same size of movement. The calendar attachments are simply arranged, and the accuracy of their performance, corresponding to a period of eight years of running of the movement in regular use, is tested by a machine constructed for that purpose. This company is enabled to produce calendar clocks of good quality for general use, at very moderate prices indeed.

E. Paulus, Philadelphia, Pa.

An escapement of his invention, to be used for what are called travelling clocks. It is the ordinary chronometer escapement, modified first by placing the locking-spring at right angles to the passing spring, and then a scape-wheel to communicate the impulse at right angles to the direction of the ordinary form. This avoids the use of a change-wheel to alter the direction of the motion, as in the case of the usual form of construction, and as in the case of the cylinder escapement in watches.

J. W. Hile, Waterville, Kansas.

A "century clock," so arranged, as the exhibitor declared, as to run a hundred years without rewinding. Mr. Hile's clock had for a pendulum a horizontal disk, moved by the torsion of a long steel spring. The escapement was very ingeniously constructed, and was entirely detached, except when communicating the impulse. The workmanship was very creditable indeed, and while it is true that by his arrangement the minimum of weight to move over a given distance for a long period before rewinding was secured, yet, unfortunately for his system, the sources of error are such that the requisite accuracy of time-keeping is not secured. Clocks have frequently been made in which the motion was regulated by the vibration of a torsion-balance, although, so far as the reporter knows, Mr. Hile is entirely original in the mode of communicating the impulse and unlocking the train of wheel-work. By having a very long spring the motion of the balance becomes very slow, and the intervals between the successive impulses and motion of the wheel-

work of the clock very long. He was very confident that his clock would exhibit the time with considerable precision. An actual trial, however, gave very unsatisfactory results. The mounting of the clock, as set up at the Exhibition, was very unstable, and it was not possible to determine what proportion of the irregularities of its rate might be due to that source. Still, it is beyond question that this form of construction, like that of the conical pendulum, will not answer for a clock to be used as an instrument of precision.

B. H. Bacon, Philadelphia, Pa.

A "lunar clock." It was an ordinary clock, with a lunar calendar attachment, but contained no novelty to be specially mentioned.

Silas Fournier, New Orleans, La.

A clock with striking attachment, to be used in giving signals for the starting of trains from a railway station. By means of a system of levers controlled by the clock-train, strokes were made upon different bells at regular intervals, and by giving in each case a different number of strokes the signal for starting different trains would be made. This system would be very convenient in the central stations of street railways where cars are to be started at short intervals and upon different lines, and where regularity is desired. The same clock contained a device to indicate the presence of watchmen at appointed hours.

Mitchell, Vance, & Co., New York, N. Y.

A collection of clocks, nicely mounted in bronze or spelter cases. The movements were constructed for them at Forestville, Connecticut, and are of the better class of cheap brass movements. The mounting was in good taste, and, in some instances, quite elaborate in design.

Lefort and Chapleau, Montreal, Canada.

A clock arranged to be used as a watchman's detector. It consisted of an ordinary clock, with a wheel or plate in front, on which the hours were marked. A knob on the outside of the case below connects with a series of pins, which may be pulled out, one every quarter of an hour. The arrangement is cheap and simple, and doubtless sufficient for the purpose of its construction.

Cyrille Duquette, Quebec, Canada.

Another watchman's detector, similar to the preceding. A series of arms is arranged, four to each hour, and, by means of a rod, one may be pulled out as it passes. This attachment may be readily applied to any clock.

Imhauser & Co., New York, N. Y.

This watchman's detector consists of a large watch movement and a device attached, by which a permanent record is made of the times when the watchman visits certain points of his beat. There is a series of twelve keys, different for each watch, each of which is kept in a designated locality, to be visited by the watchman, and by means of which he punches a paper dial (to be changed daily), showing exactly when he is at the place of each key. There is also a safety attachment to each lock, so that if the watchman has a key to open the watch a mark is punched on the paper dial, showing that this has been done.

English Clocks.

There were only two English makers who exhibited clocks, but they were representatives of the highest achievements of the art in that country.

M. F. Dent, London.

Some very beautiful clocks for the mantel. These had what is known as the chronometer escapement, with fusee and train, as in marine chronometers, the whole well finished and adjusted for action with great delicacy. He exhibited also clocks with lever escapements and flat spiral balance-springs.

Charles Frodsham & Co., London.

Parlour and ornamental clocks, in addition to electrical and astronomical clocks. They all showed evidences of exact workmanship such as characterizes the productions of this house.

French Clocks.

There were exhibited a considerable number of the well-known French clocks, and in great variety of styles. The celebrated house of Bréguet, Paris, exhibited some very fine specimens, not only in respect to workmanship in the construction of the movement, but also in respect to the decoration and style of the case.

E. Rosset, Paris.

Clocks with the movements concealed in the arbour of the hands, showing a large dial and hands in the usual way. These naturally attracted the curiosity of the visitors, the concealment being very complete.

B. Bontems, Paris.

Beautiful specimens of ornamental clocks with artificial singing-birds.

Boucher-Gravet, Paris.

A variety of clocks, which were noticeable particularly on account of their being cased in antique styles, and for the very beautiful decoration of the cases.

Eugéne Farcot, Paris.

A variety of clocks of different grades, adapted to the general purposes of commerce, into many of which he has introduced novelties, interesting and convenient. Among others was a large clock with a conical pendulum, duly compensated. There were also clocks for ships, with an arrangement for re-winding invented by Mr. Farcot and patented in the United States. There are two spring barrels, one of which winds the clock, while the other winds up again the cord. There were also clocks of different sizes, with conical pendulums, as well as a collection of very simple, efficient alarm-clocks. The entire exhibit was worthy of commendation for the variety and excellence of the productions, when the purposes of the manufacture are considered, and for the very moderate prices at which they are furnished.

Süssfeld, Lorsch, & Co., Paris.

A collection of common grades of French clocks, in marble, showing a variety of designs.

Mayet-Tissot, Morez (Jura).

Three regulator clocks. One of these had brass and steel compensation, and a large, flat pendulum ball, with metallic thermometric indicator. It had a calendar attachment, showing the days of the week and month, and the phases of the moon. It also had a pointer, to indicate the equation of time. The workmanship appeared to be excellent, but there was no opportunity to test its time-keeping properties. He exhibited, also, two regulators, with well-finished movements, and seconds pendulums, with mercurial compensation.

Meubley & Verdier, Paris.

The purpose of this device, which was exhibited in the Machinery Hall, is to indicate time or distance in connexion with cabs or coaches for hire in cities. It shows by a dial and pointer, for the tariffs fixed, the amount of hire which has accrued at any instant, and also the time elapsed and the distance traversed. It marks also upon a fillet of paper the distance passed over. The movement-indicator is in relation to time controlled by a clock movement, and in relation to distance by air compressed in a flexible tube, connected with a bellows and ratchet and wheel-work, and operated at each

revolution of the carriage-wheel. This indicator is compact, easily understood, reliable in its indications, and durable.

German Clocks.

The Black Forest region of South Germany has long been famous as the place of manufacture of the cheap wooden clocks which are in use in many countries. The movements of these clocks, it is well known, are about as bad as can be constructed, but nevertheless the ornamental cases of wood, carved with great ingenuity, and the attachment of an artificial singing-bird, or some similar device, in connexion with the striking of the hour, has kept up the demand for them as toys long after they ceased to be sought after for the purposes of marking the hour. It must not, however, be supposed that a good article of house clocks is not made in that country. Even the makers of the cheap wooden clocks make also better grades, and the total production of all kinds is the greatest of any country, excepting only the United States. This industry has flourished in that part of Germany for two centuries, and it bears the same relation to clock-making for the purposes of commerce that Switzerland does to watch-making. The annual production is stated to be about 1,800,000 clocks, of the value of nearly $4,500,000. About 14,000 persons are engaged directly or indirectly in the manufacture of clocks in the Schwarzwald, of which more than 1,400 are established clock-makers or manufacturers. The system adopted is that of the minute division of labour, with only a very limited use of labour-saving machines.

Gustav Becker, Freiburg, Silesia.

His astronomical clock has already been mentioned. He also exhibited a large collection of clocks of various grades, which were, on the whole, the best of the German exhibits in this particular department of horology. His clocks are made on the plan of the interchangeability of the parts; and in addition to finished clocks he exhibited a large collection of parts of clocks and of well-finished movements.

Conrad Felsing, Berlin.

A collection of clocks for the ordinary purposes of commerce, some of which were very well mounted in imitation bronze cases. It was understood, however, that the clock movements were manufactured in Baden.

The chief collection was exhibited by nine manufacturers, who put their productions together as a single exhibit, under the title of "Kollektiv-Ausstellung Schwarzwälder Uhrmacher." These were:

1. Aktien-Gesellschaft für Uhrenfabrikation, Lenzkirch.
2. Bened. Schwer, Jr., Triberg.
3. Ph. Haas & Söhne, St. Georgen.
4. Em. Wehrle & Co., Furtwangen.
5. Leo Kaltenbach, Furtwangen.
6. B. Ketterer Söhne, Furtwangen.
7. Lorenz Bob, Furtwangen.
8. Maurer & Höfler, Eisenbach.
9. J. Bapt. Beha & Söhne, Eisenbach.

The united collection gave a great variety of sizes and styles of finish. The movements were well finished for the particular grades of clocks exhibited, which were principally of the grade known as "Schwarzwälder Uhren." Among them were regulators with well-finished trains and escapements, but with wooden pendulums, made respectively by L. Kaltenbach, L. Bob, and B. Ketterer & Sons; also regulator clocks, with well-finished movements and compensated pendulums, by Maurer & Höfler, and the Aktien-Gesellschaft. The exhibit contained, also, three trumpet clocks, by Em. Wehrle & Co., worthy of special mention. There was also a large number of what are called cuckoo clocks, with elaborately carved cases. The reader not familiar with these designations will understand that they refer to the musical attachments connected with the striking parts, by which a trumpeter performs on his instrument, or a cuckoo comes out and sings, as the hours are struck. What is worthy of notice in respect to these productions is their cheapness when the labour necessarily expended is taken into consideration.

MAURER & HÖFLER, Eisenbach.

A regulator clock, with brass and steel compensation, in an elaborately ornamented case. They exhibited, also, a watchman's clock, of simple construction.

CARL & LUDWIG HAAS, St. Georgen.

Cottage and octagon clocks, with brass movements, constructed upon the American plan.

SWISS CLOCKS.

There were only two exhibitors of clocks from Switzerland, and of these only one contributed articles which came under the examination of the Judges on horological instruments.

LEUENBERGER & SON, Summiswald, Berne.

There was one regulator clock, with compensated rod, and two clocks for ordinary use, constructed in the Swiss fashion. The workmanship was good.

M. HIPP, Neuchâtel.

Electric clocks, the performance of which fully corresponded with his reputation as an accomplished manufacturer of instruments of precision for the keeping or registration of time. The particular examination of these clocks was assigned to the Judges upon Electrical Apparatus.

IV. MARINE CHRONOMETERS.

The number of marine chronometers exhibited was such as to give a correct idea of the condition of this manufacture in the different countries whose productions were on exhibition. This instrument in its most perfect form has resulted from the demands of navigation, and upon its performance the safety of commerce in a large measure depends. As an instrument of precision it is entitled to the highest rank, and especially when it is considered that, unlike in the case of an astronomical clock, it is not almost daily compared with actual time observations to determine its error and rate, but, on the contrary, it is to be depended upon for weeks and even months, and the time observations are solely to find the local correction, and hence the longitude at sea.

The method of construction has long been well established, and the only differences usually to be found in the work of different makers, beyond minor differences in the arrangement and size of the parts, are in respect to the adjustment for temperature. The isochronism of the action of the balance-spring is of the first importance, and this adjustment has, ever since the chronometer has been depended upon to find the ship's place at sea, received the most careful attention from the makers of these instruments. The adjustment is well understood, and is not difficult to effect within moderate limits, especially since there is provision made that the instrument shall perform its functions always in the same position. The chief difficulty is in the correction for temperature, and it is to accomplish this that many devices have, within the last twenty or thirty years, been proposed and applied. The use of the simple bi-metallic rim of brass and steel was for a long time considered to be sufficiently exact, and there are many reputable makers who still adopt the simple compensation. But it is well known that even if it be desired to compensate for the principal effects of temperature, such as those resulting from the change of the dimensions of the balance itself, and the change in the length of the balance-spring and in its elastic force, the action of the laminæ in changing the position of the compensating weights cannot provide exact compensation over a considerable range of temperature, because the law of variation in the one case is not precisely the same as in the other. Hence there will be two points, or temperatures at which the compensation may be perfect, but at other temperatures, on account of the irrationality of the compensation, there will be outstanding differences which must be provided for in some other way. And further, when an extreme limit of precision is sought, the nicest adjustment of the isochronism of the balance-spring becomes complicated with the temperature error, so that a limit is reached

beyond which we can hardly expect to progress. It is easy to understand the principal part of the secondary error, and it is not difficult to provide for it to a considerable extent. All of the devices for auxiliary compensation which have been used, and so frequently described as to require no particular description here, do reduce the secondary error very much, but they do not remove it entirely. It has been suggested that it is of little importance to attach a mechanical device to the balance to provide for this error, which, by the irregularity or uncertainty of its action, may be the source of other mischievous errors, whose existence even would not be suspected in the absence of actual time observations for comparison, when the law of the irrationality of the compensation may be determined for each chronometer in actual use, and the proper corrections to be applied to the rate tabulated for each degree of the thermometer. Various formulæ have been proposed for the calculation of these errors, and, as might be expected when the numerical constants have been determined for any particular chronometer, a close approximation to its actual rate at a given temperature can be made. That the law is approximately known is shown clearly enough by the circumstance that a single formula may be applied to a great number of chronometers similarly constructed. Still, there can be no question that when an extreme limit of precision is sought the mathematical expression of the law of the residuals would be different for each chronometer; and if this method is to be depended upon solely a thorough discussion of an extended series of comparisons with an accurate standard should be made for the purpose of determining the particular formula and the value of the constants. Such an investigation ought to include conditions for determining outstanding errors of isochronism at different temperatures, and for different degrees of viscosity of the oil. The inherent difficulties of the problem, and the actual demands of those who are to use the chronometers, are such that it has become desirable to provide a mechanical correction which, while not giving results of the greatest possible accuracy for a particular instrument, is yet sufficient for the actual necessities of the case. This avoids, too, the necessity for a continuous and frequent thermometric record, which is indispensable when the secondary correction is to be computed or derived from a table previously prepared.

Nearly all the chronometers exhibited had some such device, and in the absence of conclusive trials of the accuracy of the performance of each it was often necessary to judge of the plan by a simple inspection of its construction, assuming that a skilful maker could effect the actual adjustments necessary.

American Chronometers.

Specimens of the work of the two principal American manufacturers of marine chronometers were shown at the Exhibition. Of these, Messrs. John Bliss and Co., of New York, alone entered chronometers for competition for an award, and the exhibit made by this house will be first considered.

John Bliss and Co., New York, N. Y.

It is usual for American manufacturers to import the *ébauche* from England, and the work performed by them consists in finishing up the parts of the train, and in making the adjustments for isochronism and temperature upon which the time-keeping properties depend. Messrs. Bliss and Co., however, exhibited chronometers which had been wholly constructed by them, and hence of strictly American manufacture throughout. One of these was taken down, and all its parts minutely examined by the Judges, and the result was that the workmanship was found to be excellent in the case of every part. All the necessary conditions for smooth action of the train were completely satisfied, and it remained only to make actual timeing test in order to determine whether the requisite adjustments of the balance and of the balance-spring had been attended to. The compensation for temperature was made in the usual way, with an additional contrivance to provide mechanically for the irrationality of the compensation, and since the device used is as simple and efficacious as any which have been proposed, its description will not be out of place here.

The main compensation is that usually employed,—brass outside, steel inside. It is, however, cut apart somewhat farther from the arm than ordinarily, in order to give a sufficient length to the laminæ. Auxiliary laminæ, considerably thinner than those of the main compensation, and with the brass inside and steel outside, are provided, which are secured by means of steel screws which pass through the feet left on the auxiliary laminæ and the rim of the balance, which screws also hold the mean time regulating nuts, as usual. Small steel check-screws are provided, passing through the laminæ, their points just touching the auxiliary laminæ.

To understand the action of the auxiliary, it is necessary to keep in mind the operation of the ordinary compensation in different temperatures. If such a balance be adjusted so that its rate will be mean time in the temperatures of 100° and 40° Fahrenheit, it will gain about three seconds daily in the intermediate temperature of 70°, which amount is a fair average for this intermediate error, which is seldom found to be as small as one second, while it is often as much as six seconds in the daily rate. If the same balance be adjusted, so that its rate will be mean time in 100° and 70°, at 40° it will lose about six seconds daily. If adjusted to mean time in 40° and 70°, it will lose about the same amount at 100°. Leaving out of question the cause of this, it is evident that the compensation weights move out from the centre of the balance too much in cold, and that they do not move inwards sufficiently in heat. What is required is to lessen the effect of the compensation in cold and increase it in heat. This is effected with this auxiliary balance, as follows: when the temperature is raised to 100°, in addition to the inward movement of the main compensation, the outer laminæ press on the weaker ones, and overcome the tendency of the latter to move outward. Therefore all the compensation weights move inward. With a decrease of temperature to 40° the main compensation moves outward; but now, while the laminæ move outward, carrying no weight but their own and the small check-screws, the interior laminæ move inward, the movement of their weight-screws counteracting a portion of the effect of the main compensation.

The auxiliary compensation most frequently used differs from this in having a rigid steel segment screwed to the arm and concentric with the centre of the balance. On the inner side of this segment a similar auxiliary is attached, and the rest of the construction is the same as that above described. There is, however, this difference in the action: when the temperature is decreased to 40° the segment does not change its shape, the auxiliary laminæ only moving inward to effect separation. If, therefore, the auxiliary laminæ spring slightly against the point of the check-screws, or there is, from long contact, a slight adhesion of the parts, there is not that sudden and decisive separation that takes place in the form first described, and no action of the auxiliary until it does take place. Besides, the segment is one more part to make, while the compensation pieces are already part of the balance, and, when the segment is attached, make an additional joint, of which there should be as few as possible in a chronometer balance.

The chronometers made by Messrs. John Bliss and Co. have long maintained an excellent reputation, derived from their reliable performance at sea, as well as in observatories. It would, therefore, seem unnecessary to have attempted a trial at the Exhibition; but, confident of the superiority of their productions, they were anxious to have the chronometers submitted to rigorous trials. This could not be done to an extent sufficient to test the action of the auxiliary compensation at many different temperatures, or even at the proper extreme and middle temperatures; but the requisite astronomical instruments being in position as a part of the exhibit made by the United States Government, it was possible to make a trial sufficient to indicate the merits of these chronometers. Accordingly, it was undertaken, and the reporter has to regret that the arduous duties devolving upon him in the examination of so many different exhibits in the limited time allotted made it impossible to make as extended a trial as he desired. There being no astronomical clock in position in connexion with the transit instrument, the time was carried from one observation to another by means of four excellent chronometers not under trial, and hence kept undisturbed, and at a temperature as uniform as possible. The chronometers exhibited by this house being all

similar in construction, and all apparently equally well finished, four only were subjected to trial in connexion with those of other makers. These were numbered 2716, 2768, 2769, and 2770. The trials extended only through eight days, and the several results are shown below. To determine whether the adjustment for the isochronal action of the balance-spring in long and short vibrations was properly made the mainsprings were set back two turns and a half, and then the chronometers were wound to 12*h*., as shown by the indicator on the dial. The balances were now moving through short arcs, and the rates thus found, compared with the rates in long arcs when the tension of the springs was restored to its normal arrangement, and the chronometers wound up, indicated the character of the isochronal adjustment of the balance-springs. For temperature, they were kept 48 hours in a refrigerator and 48 hours in a heated room, and the rates found at the extremes, in connexion with those in the middle temperature, show, in a degree, the character of the compensation, although not as fully as the reporter desired to make the test, and as the excellent instruments under trial deserved. The results of the comparisons are shown by the following table:

Period.		Balance vibrating in	Average Temperature	Daily Rate of			
				No. 2716.	No. 2768.	No. 2769.	No. 2770.
			°	s.	s.	s.	s.
1876.	July 27 to July 29	Short arcs	75	+2·89	+0·95	−2·59	−0·80
	„ 29 „ 31	Long arcs	72	+0·92	−1·55	−0·22	+1·38
	„ 31 to Aug. 2	Cold	38	+1·72	−0·12	+0·24	+3·61
	Aug. 2 „ 4	Heat	88	+0·44	−0·78	+0·45	+1·45

When the trials began the mainsprings were set back so as to act with greatly-diminished force, and hence the balances vibrated through very short arcs. After having run in this manner for two days, the springs being set at their proper tension and wound up, the balances again moved through long arcs of vibration. The differences of the rates thus found show the outstanding errors of the adjustments for isochronism. Thus we have:

Chronometer.	Difference between Long and Short Arcs.
	s.
No. 2716	−1·97.
No. 2768	−2·50.
No. 2769	+2·37.
No. 2770	+2·18.

The smallness of these errors shows the excellence of these adjustments. It will be observed, further, that in the case of two of these chronometers the acting parts of the balance-springs were too short, while in the case of the other two they were too long.

The trials for temperature errors, although sufficient to show that the compensation was well made, yet do not indicate fully the effect of the secondary or auxiliary compensation. On account of the lack of necessary facilities the rates at the proper middle temperature could not be determined, and the reporter does not know what the critical temperatures were for which the adjustments for compensation were originally made. Still, it is clear beyond question that the secondary error is very much reduced by the auxiliary compensation. The adjustments of chronometer No. 2769 appear to be closer than those of the others, although all of them are far within the limits recognised as the proper standard for first-class marine chronometers.

While it cannot be urged as an objection to a particular chronometer that the different parts were manufactured by different persons, provided that the adjuster has finally performed his duty, it is nevertheless certain that when the whole has been constructed at a single establishment it furnishes evidence that the maker is familiar with all the details of the manufacture. As already stated, the chronometers exhibited by Messrs. John Bliss & Co. where wholly of their own manufacture, and a critical examination failed to reveal any defects of construction or of details of workmanship. On the contrary, the whole execution was found to be of a character such as to entitle them to the highest commendation. The records of the performance of their instruments upon long sea-voyages were also carefully examined, and these thoroughly established the fact that they were fully as good as those of the most renowned makers in

other countries where this industry has kept pace with the most exacting demands of navigation.

T. S. & J. D. Negus, New York, N. Y.

In the United States Government Building, as part of the Naval exhibit, Messrs. T. S. & J. D. Negus, of New York, exhibited several marine chronometers. This house furnishes the chronometers required by the Government, and, besides, has long had an established reputation in connexion with the mercantile marine for the excellence of the instruments sent out. On account of the regulations in respect to the exhibits entered for competition these chronometers could not compete for an award, but are entitled to proper mention in this general report. Two of them, numbered respectively 1447 and 1595, were subjected to trial in connection with the other chronometers under examination, and under precisely similar circumstances, and the results were as follows:

Period.	Balance vibrating in	Average Temperature.	Daily Rate of No. 1447.	Daily Rate of No. 1595.
		°	s.	s.
1876. July 27 to July 29	Short arcs	75	−1·42	−1·01
„ 29 „ 31	Long arcs	72	−0·57	−1·25
„ 31 to Aug. 2	Cold	38	+2·91	+0·66
Aug 2 „ 4	Heat	88	−0·15	−1·08

The difference of the rates for long and short arcs was, therefore + 0·85 s. for No. 1447. and — 0·24 for No. 1595, thus showing that the adjustments for isochronism were exceedingly well made. The balances had simple compensation, and the outstanding temperature errors were shown to be very small. Sometimes it has happened in trials extending over a long period that the simple compensation has given results fully as accurate as those for the cases where the auxiliary compensation has been applied. In general, however, such is not the case, the exceptional results being due to other compensating causes. Hence it may be suggested that the excellent instruments of Messrs. Negus would be still further improved by this additional precaution against errors due to changes of temperatures, especially for the reasons already mentioned, as resulting from the requirements of navigators who rely directly upon the indications of these instruments.

Some of the chronometers exhibited by Messrs. Negus were adapted to the purposes of astronomical observations with the electro-magnetic method of recording the times of transits of stars or of other observations. They were provided with break-circuit attachments. The wheel-work of the chronometer is made to break a metallic circuit at the end of each second by means of a wheel of sixty teeth acting on a jewel pallet attached to a light steel spring, the spring having a platinum screw in it, and the head of the screw banking on the point of another platinum screw projecting through a fixed insulated stud connected with terminals on the outside of the chronometer. The electric circuit is interrupted for a period of about one-fortieth of a second while the platinum points are separated by the action of the wheel upon the jewel pallet. The motion of the balance of the chronometer is not disturbed in the least by the passage of the electric circuit, since the breaking of the circuit is performed by a supplementary wheel having no connexion with the escapement. The arrangement of a break-circuit attachment, such as that just described, in connexion with marine chronometers, has been made by many other makers, but Messrs. Negus were the first to employ in connexion a condenser, to prevent the production of an electric spark at the platinum points as they are separated in opening and closing the circuit. The advantage of this is obvious. Not only is the deflagration of the platinum points prevented, so as to insure continuous action of the break-circuit, but any irregular adhesion is prevented, so that the force employed in the action of the break-circuit wheel is constant, and hence produces no change of the rate, whether the chronometer is actually breaking an electric circuit or not. The condenser is constructed of alternate layers of paraffine-paper and tin-foil arranged in two distinct series insulated from each other, and each series is attached to the terminals on the outside of the chronometer. The reporter has had actual experience with the break-circuit chronometers made by Messrs. Negus, with the condenser for arresting

the spark applied, and he can bear testimony that their performance as time-keepers, as well as the certainty of the action of the break-circuit attachments, have been all that could possibly be desired.

E. Paulus, Philadelphia, Pa.

This manufacturer exhibited a marine chronometer movement, and also a hand model of the escapement, constructed by him. There is a fork like that in the lever escapement, while the other extremity of the lever is geared into a pinion. The arbour of this pinion has, on the upper side, a notch in which the teeth of the scape-wheel rest. The impulse is given by a pin on the roller acted upon directly by the scape-wheel. The fork and the balance are moving in the same direction when the impulse is given. The performance of this movement as an instrument of precision had not been subjected to any critical test, and it was not submitted to trial at the Exhibition.

English Chronometers.

The English chronometer-makers have long been known throughout the world as occupying a high rank in the profession. It was in that country that the marine chronometer, as we have it at the present day, had its origin. The liberal reward offered by the British Parliament, more than a century ago, for the discovery and application of a method of finding the longitude at sea within the limits demanded by the necessities of navigation, led to the production of the first instrument of this kind which could truly be called an instrument of precision. Although its performance was such as to secure the promised reward, the limits within which the determination of the longitude must lie being exceedingly liberal, from the present stand-point of science, yet it was far from being such an instrument as would pass muster at the present day. The immense mercantile and public marine of Great Britain has given employment to a large number of skilled workmen in the construction of the necessary chronometers, and, besides, the regular trials at the Greenwich Observatory of a large number of these instruments, from the most successful of which the Admiralty selected those required for the navy, have served to stimulate the makers to the production of the very best possible specimens of their work. As might be expected, all that could be derived from scientific construction and exquisite workmanship has been achieved, and the annual records of the trials made at the astronomical observatories show a steady approach towards greater perfection.

The attention of the English makers has been chiefly directed, of late, to the perfection of the compensation for temperature effected by the balance, and, as a consequence, a large number of ingenious contrivances have been proposed and executed. One of the exhibits, that of Messrs. Charles Frodsham & Co., of London, contained a collection of all the varied forms of balances with auxiliary compensation which had been tried by them since this subject began to receive special attention. The study of this collection was very interesting, and it served to convey in a very forcible manner the nature of the difficulties which the successful chronometer-maker has to encounter.

The trials of marine chronometers, made at the Greenwich Observatory, extend, in the case of each instrument, over a period of twenty-nine weeks. In the course of the trials they are subjected to extremes of temperature of 35° and 95° Fahrenheit, and from the steadiness of the rate during the whole period, in connection with the greatest difference between one week and the next, including the change from cold to heat, the trial numbers are derived which determine the rank which the chronometer takes among a large number on trial.

All of the English makers whose chronometers were exhibited have at various times had their instruments included in the Greenwich trials, and all of them had succeeded in taking high rank in these trials. The fact that only first-class instruments are put into these competitive trials attests the merit which belongs to a successful competition, and each of these exhibitors had at some time achieved that success.

When it was determined to test the adjustments of the marine chronometers by an actual trial at the Exhibition, the representatives of the English chronometer-makers whose chronometers were on exhibition were requested by the Judges to furnish some of their instruments for the trial. This resulted in a

consultation by the persons interested, and the sending of a written communication to the Judges, in which it was stated that, as no previous intimation had been given that such trials would be made at the Exhibition, that since no such trials had been made at any previous International Exhibition, and that since they could not advisedly select the proper instruments from among those on exhibition, justice to the makers whose agents they were required them to decline to accede to the request. This communication was signed by the persons representing Charles Frodsham & Co., M. F. Dent, J. Sewill, Victor Kullberg, and Thomas Mercer. Accordingly the trials were commenced without including any English chronometers, but before the close, Mr. Gibson, representing James Poole and Co., of London, who had not signed the communication above mentioned, and who had not been consulted, as it seems, upon receiving notice that the trials were in progress, promptly sent to the Judges two of Poole's chronometers to be subjected to any trials desired.

M. F. Dent, London.

Several marine and surveying chronometers. The former were of the usual construction, and had different forms of auxiliary compensation for the balance. In two of them the auxiliary compensation was by means of auxiliary laminæ, with curb-screws to limit the action, constructed in the usual form. In the case of one chronometer the balance was of a new form, invented by Mr. Dent. There is a flat rim of brass and steel, the latter below. This carries a bar on which is placed the compensating weight, and this bar has the laminæ reversed, namely brass below and steel above. The action of the balance-springs was found to be very symmetrical, and all the indications short of an actual trial were of workmanship of the first order. The surveying chronometers, intended for field and exploring expeditions, were smaller than the smallest size of marine chronometers, but much larger than the usual pocket chronometers. The balances had auxiliary compensation in the ordinary form. The balance-springs were of the form designated as "tria in uno," by which it is to be understood that the spring is cylindrical, terminating above and below in flat spirals. The object of this form is to diminish as much as possible the errors of the action of the spring due to changes of position, and this is important in the case of an instrument which is to be transported in the pocket of the observer. Another essential was very ingeniously provided for. There was applied a novel and effective method of preventing overbanking.

Charles Frodsham & Co., London.

Several marine chronometers which were exquisitely finished, and which were doubtless good instruments, although, for the reasons already mentioned, not subjected to any trial for their adjustments. Most of those exhibited were of the ordinary construction. There was one which had an extra large roller for the escapement, and provision was made by which a double vibration might be made while unlocking only once. In connection with this exhibit was the collection of various forms of compensation balances already mentioned. There was a marine chronometer with an attachment for electric connection to control the vibrations of a magnet armature. There is a long and delicate spring placed with one end bearing against a platinum point. In the middle of this spring is a jewel tooth, which is acted upon by a wheel having sixty teeth and revolving once a minute. The spring is made very light and very long, so as not to produce any sensible effect upon the rate of the chronometer, whether it be used in the electric circuit or not. The application of a condenser, to prevent deflagration at the point of contact by the spark at the opening and closing of the circuit, would be a desirable addition to this instrument.

J. Sewill, Liverpool.

Several marine chronometers. They were of the usual construction, with simple compensation, and their merit consists chiefly in the good quality of the work in connection with the very moderate prices charged. Sewill's chronometers have stood well in the Greenwich trials, but in these cases they were probably superior instruments to the cheaper ones exhibited at Philadelphia.

All of their instruments, however, are sent to the Liverpool observatory to be rated and tested before they are sent out.

V. Kullberg, London.

Two sizes of marine chronometers. The larger, eight-day chronometers, had the parts connected with the escapement attached to a separate plate. The compensation had an auxiliary to modify the action in the extremes by means of a curb brought into action at the proper time. The smaller two-day chronometers were similarly constructed and were equally well finished. One of the chronometers exhibited had a flat rim balance, steel uppermost, similar to that in the Dent chronometer, already mentioned. The arrangement of the adjustment of the compensating weights, however, was better than in Dent's form. The balance-springs were hardened and tempered without blueing, for the avowed purpose of preventing the usual acceleration due to new springs. They were lacquered to prevent their rusting.

Thomas Mercer, London.

A similar collection of chronometers, which were constructed in the usual manner. There were no novelties worthy of particular mention. The finish was good and the springing was apparently properly done, although no actual trials were made to determine the accuracy of the adjustments.

Messrs. James Poole & Co., London.

These were the only English makers whose chronometers were subjected to any trial whatever. Two chronometers were taken from among those on exhibition, and were subjected to partial tests. From the statement already made of the circumstances of the case, it will be understood why these chronometers were not received by the reporter in time for a trial for the adjustment of the balance-spring. The finish of the parts of these chronometers was excellent, and the action of the balance-springs entirely symmetrical. This house is justly regarded as of the highest rank in England; and the reporter does not doubt that if the chronometers had been received in season for the trial of the isochronism of the balance-springs, they would have endured the requisite test as completely as they did that for temperature. So far as compared, the two on trial gave the following results:

Period.	Balance vibrating in	Average Temperature.	Daily Rate of No. 5699.	Daily Rate of No. 5700.
		°	s	s
1876. July 29 to July 31	Long arcs	72	+3·07	−0·65
„ 31 to Aug. 2	Cold	38	+3·29	+1·76
Aug. 2 „ 4	Heat	88	+2·77	0·00

Chronometers provided with Poole's auxiliary compensation have generally ranked very high in the Greenwich trials.

French Chronometers.

There was but a single exhibitor of chronometers from France, although that country occupies a high rank in the manufacture of these instruments. Trials are regularly made at the *Dépôt des Cartes et Plans de la Marine*, at Paris, in some respects similar to those at Greenwich, and usually the productions of all the principal French makers are included in these trials. The chronometers are tried in heat, in cold, and in the ordinary temperature of use. Their rank is then determined by adding to the error in the ordinary temperature the greatest error in heat or cold.

A. H. Rodanet, Paris.

Marine chronometers, constructed entirely in his own establishment. The arrangement of the parts was somewhat different from what is usual in the American and English chronometers. The escapement was exposed, and the motion of the balance-spring quite different from the usual motion of cylindrical springs, effected by means of a peculiar terminal curve. Mr. Rodanet's chronometers have shown very steady rates on long sea voyages, and have taken high rank in the Paris trials. The balances have simple compensation.

One of these chronometers was subjected to trial for the accuracy of its adjustments, and the following results were obtained:

Period.			Balance vibrating in	Average Temperature.	Daily Rate of No. 421.
				°	s
1876.	July 26 to July 29	-	Short arcs	75	−9·64
	„ 29 „ 31	-	Long arcs	72	+1·06
	„ 31 to Aug. 2	-	Cold	38	+2·01
	Aug. 2 „ 4	-	Heat	88	+1·00

It appears, therefore, that the temperature errors are small, but that the isochronal adjustment of the balance-spring requires further correction. It should be stated, however, that the mainspring was let down so far that the vibrations of the balance were very short, and hence the test was much more severe than would correspond with any fluctuations to which the motion of the balance would be subjected in actual use.

Dutch Chronometers.

There were chronometers exhibited by two Dutch makers. The long career of this nation in extensive commerce on the seas would lead us to expect that of necessity their horologists would devote considerable attention to the construction of marine chronometers. The two manufacturers whose productions were exhibited have secured an excellent reputation for their instruments.

A. Hohwü, Amsterdam.

His excellent astronomical clocks have already been noticed. He exhibited also marine chronometers constructed by himself. The balances had auxiliary compensation in the ordinary form, with auxiliary laminæ and curb-screws to control the action in the usual manner. Two of these chronometers were subjected to trial for the accuracy of their adjustments, with the following results:

Period.			Balance vibrating in	Average Temperature.	Daily Rate of	
					No. 575.	No. 596.
				°	s	s
1876.	July 27 to July 29	-	Short arcs	75	−153·93	−16·18
	„ 29 „ 31	-	Long arcs	72	−152·06	− 0·45
	„ 31 to Aug. 2	-	Cold	38	−215·14	− 1·26
	Aug. 2 „ 4	-	Heat	88	−155·90	+ 3·12

It is evident that No. 575 needed overhauling, and that it was not in proper condition for trial. The probability is that it had been injured in some way in transportation to Philadelphia. In the case of No. 596, the results go to show that the isochronal adjustments are yet imperfect. The springs were let down so much that the vibrations were very short, and hence the full effect of this error is exhibited. The temperature error is larger than ought to be expected, especially since the balance had auxiliary compensation.

A. De Casseres, Amsterdam.

Marine chronometers of the usual construction and with well finished movements. One of them was subjected to trial, and the results were as follows:

Period.			Balance vibrating in	Average Temperature.	Daily Rate of No. 573.
				°	s
1876.	July 27 to July 29	-	Short arcs	75	−10·17
	„ 29 „ 31	-	Long arcs	72	− 8·49
	„ 31 to Aug. 2	-	Cold	38	−15·96
	Aug. 2 „ 4	-	Heat	88	− 8·06

The outstanding temperature error is considerable, but the difference between long and short arcs is so small, considering the extremely short arcs of vibration which were obtained in the trial, that the isochronal adjustment must be regarded as entirely satisfactory. The chronometer had not been properly rated, or else it had suffered some disturbance in transportation.

Swiss Chronometers.

The attention of the Swiss horologists is directed principally to the production of the best possible specimens of pocket chronometers, and, consequently, they have not produced as many marine chronometers as might be expected, considering simply the magnitude of the horological industry in that country. However, the Swiss makers have, from time to time, produced some excellent marine chronometers, the finish and the adjustments being in complete accordance with their known skill as horologists.

H. Grandjean & Co., Locle.

Several marine chronometers, showing excellent workmanship, and having certificates attesting their running qualities, as determined in the observatory at Neuchâtel. These instruments having been thus already subjected to trial in an astronomical observatory, no further trials were necessary. The results obtained at the observatory of Neuchâtel, and derived from a trial extending through eight weeks, were as follows:

No. of Chronometer.	Mean Daily Rate.	Mean Daily Variation.	Variation for 1° Centigrade.	Difference before and after Oven.	Difference between first and last Week.	Difference between the Extreme Rates.
	s	s	s	s	s	s
91 - -	+1·15	±0·16	+0·09	+1·55	+2·06	2·96
92 - -	+1·87	±0·18	+0·04	−0·48	−0·27	1·29
94 - -	−0·81	±0·08	+0·04	−0·19	+0·57	0·94

Nos. 86, 87, and 90, which were exhibited by the same makers, gave also excellent results in the observatory trials. The trials were simply the running rate in the ordinary changes of temperature, with the exception of a single day, during which they were kept in heat. The results are therefore not sufficient to show how closely the isochronal adjustments were made, nor the inequalities of rate due to the irrationality of the compensation. Still, the daily record of No. 94, while under trial, was extraordinarily good, and there can be no question but that it is a superior instrument. In the trials of chronometers made at Philadelphia, two of the Grandjean chronometers were used, in connection with others, to carry the time forward from one night's observations with the transit instrument to another, and their performance was found to be entirely satisfactory.

Spanish Chronometers.

D. Juan Homs, Barcelona.

A marine chronometer constructed by himself, with a device in connection with the escapement to secure a constant force in the communication of the impulse to the balance. The instrument exhibited was so poorly constructed that it was impossible to form any estimate of the character of his alleged improvement.

V. Pocket Chronometer and Watches.

It has already been remarked that the number of fine clocks exhibited was very small, the number and variety being confined chiefly to the clocks of commerce, known generally as house clocks. In the case of marine chronometers, the number exhibited was considerable, and the productions of those known to be the most successful manufacturers were well represented, although many makers of established reputation did not exhibit. While it is true also that several eminent manufacturers of pocket chronometers and watches did not send their productions to the Exhibition, yet the exhibits made represented in the most satisfactory manner the productions of every country in which the watch-making industry has any importance in respect to either the quantity or the quality of the productions. Not only was the number of exhibitors large, but the number of specimens of each grade of manufacture was also large. In one instance the number of specimens shown by a single exhibitor exceeded two thousand. We may therefore, by considering in detail the productions of the different countries, as shown in the International Exhibition, form a correct idea of the present state of this most important industry, and by comparison of results we may derive very definite information in regard to the progress which has been made in perfecting the movements of watches of every grade.

American Watches.

American Watch Company, Waltham, Mass.

This was the most extensive exhibit of watches shown; it consisted of about 2,200 completed watch movements, the majority of which were provided with gold or silver cases. This represented the product of their factory for six working days. The extent of the exhibit, the conspicuous manner in which the watches were displayed, and the beauty of finish of the movements and the cases, all contributed to attract daily the attention of crowds of visitors. This was the first International Exhibition at which the products of our watch manufactories were exhibited, and on account not only of the magnitude which the industry has assumed, but also on account of the excellence, of the productions, it is proper to describe here the development of this branch of our manufactures.

Until the inauguration of this new enterprise in 1850, the watches and pocket chronometers used in the United States were imported from abroad, and principally from England and Switzerland. The prevalent notion had been that the production of these delicate machines could only be made with success in those countries where labour was cheap, and where the training and secrets transmitted from one generation of watch-makers to another made possible anything like perfection in the art. It is true that several of our artisans had shown great excellence in the finishing and adjustment of marine chronometers, so much so that it was well established that there was no lack of intelligent mechanics whose understanding of the principles of horological science, and of their application in practice, was beyond question; but when the requirement was a pocket time-keeper, even of inferior quality, the field of production looked uninviting from a commercial point of view. It was fortunate, perhaps, that the attempt finally made had been delayed so long, because an opportunity had been afforded to develop among our countrymen that ingenuity which has astonished the world in the production of machinery in a great degree automatic, or in the highest degree labour-saving in its operation. Not only this, but the fabrication by such machinery of the parts of other machines with such uniformity that the similar parts of these machines, made in any number whatever, become interchangeable, had arrived at a high degree of perfection. This system forms so important a part now of all our production of machines, for whatever purpose used, and is hence so well understood, that it is necessary barely to allude to the fact. Independently of the advantages which result from the mere perfection of the manufacture in the adjustment of the parts, essentials of the highest importance, the convenience of this system in facilitating repairs is its most important feature in an economic point of view. This, it is well understood, is all-important in the case of those machines in most general use, such, for example, as sewing-machines or agricultural machines. How much more important in the case of such delicate machines as watches, which have become the necessary companions of persons in every walk of life, and whose proper fabrication by the ordinary methods can only be undertaken by the most experienced workmen. The development of our watch-making industry has been a part of this scheme, and there can be no doubt from the results already achieved that this is its triumph.

Now that the results are before us, we can imagine the scheme faintly outlined, but still distinct and inviting, in the minds of our countrymen who first conceived the project to manufacture watches by machinery, and thus by the application of forces other than human, to overcome the commercial difficulty resulting from the difference of wages here and abroad. These were Aaron L. Dennison and Edward Howard, of Boston, Massachusetts. The former was an expert watch-repairer, and the latter a skilled clock-maker. In 1848, Mr Dennison suggested to Mr. Howard the project of attempting the manufacture of watches by machinery, and two years afterwards, in company with Samuel Curtis, also of Boston, they established at Roxbury, Massachusetts, a factory of this kind, and commenced the manufacture of watches which bore the name "Boston Watch Company." Subsequently they removed their establishment to Waltham, ten miles from Boston, and there, having organised as an incorporated company, they erected a small factory where now stands the imposing establishment of the present American Watch Company. At the expiration of three years the company became bankrupt, on account of un-

expected obstacles encountered, and their property was purchased at an assignee's sale, by R. E. Robbins, of New York, for the firm of Appleton, Tracy, & Co. By an act of the Legislature of Massachusetts, a corporation was created, to be known as the "American Watch Company," with a capital of $200,000, which was soon advanced by subscriptions to $300,000. This company succeeded to the business already established, and has continued to develop it, until it now possesses by far the largest manufactory of the kind in the world. The capital has been increased by subscriptions from time to time until now it amounts to $1,500,000.

In the hands of managers who had a mastery of the commercial machinery, and operated by mechanics whose ingenuity and intelligent application of the principles of horological art and science made the work of a quality to merit success, this company, in an untried field, and against the opposition of prejudice and cheap foreign production, have fought their way to unparalleled success. The factory is located in a quiet suburban town, free from the dust and annoyances of the city, so that with extensive buildings, supplied with every appliance in the way of machines which it would seem that human ingenuity can devise, and surrounded by the neat cottages of the workmen, nature and art conspire to facilitate a work so delicate as the production of a watch such as modern demands require.

The factory consists of twenty-one departments, each under the proper foreman and his assistants. The whole is in charge of C. Vanderwoerd, as mechanical superintendent, whose skill as a mechanic is sufficiently attested by the machines for watch-making which attracted the attention of crowds of visitors in Machinery Hall during the whole period of the Exhibition. For the sake of giving, as it were, an inside view of this establishment, it may not be amiss to particularise these departments. They are:

1. An extensive machine-shop, including draughting-room, where the various machines for watch-making are constructed, which therefore becomes the foundation of all.
2. The press-room, where the metals, brass, steel, copper, &c., are prepared for punching, and then punched into the blanks for wheels, regulators, ratchets, clicks, indexes, hands, dials, &c., the larger brass pieces, such as plates, bridges, and barrels, being punched for them from their own patterns at Waterbury, Connecticut, thus avoiding the freight on whole brass sheets and return chips to that great centre of brass-working for New England.
3. Frame-rooms, where the brass and nickel frames are made complete up to the process of stoning.
4. Dial-making and enameling.
5. Dial-painting.
6. Flat steel-work made and finished.
7. Jewel-making from the rough stone to the finished hole, using diamond and sapphire as the working materials, and ruby, chrysolite, garnet, and aquamarine for the jewels.
8. Train-making, including barrels, wheels (except scape-wheels), barrel and pallet arbours, balance-staff, pinions, cannon-pinion.
9. Hardening and tempering of *all* steel pieces.
10. Train-finishing.
11. Screw-making.
12. Setting jewels in watches.
13. Hand-making.
14. Escapements, including fork, pallets, roller, scape-wheel, and putting them together.
15. Balance-making.
16. Springing, including hair-spring and mainspring-making.
17. Gilding, including stoning and frosting.
18. Assembling the parts of the watches.
19. Adjusting the movements.
20. Engraving.
21. Silver case-making, in several divisions.

Supplementary to all these, there are all the needful smaller rooms such as for blacksmithing, piping, carpenter's shop, packing, &c. The motive power is supplied by two engines of 25 and 35 horse-power, respectively, and the number of persons employed exceeds 800, half of either sex. There are many important operations in the manufacture of watches by this method where the

delicate manipulation of female hands is of the highest consequence, and it ought to be mentioned here that for this labour the amount of wages paid by the company is determined by the skill and experience required, not by the sex of the operatives.

It is not the purpose of this report to give a description of the details of the processes, and only such allusion to them will be made as may be necessary to make clear the matters under consideration. As regards the individual machines employed, in number the aggregate of the various kinds amounting to thousands, each of its kind performs some special work, either in forming or finishing pieces, and it performs those operations always in the same manner. Sometimes the functions of the machines are performed automatically, but generally the human operator is present to direct its movements; nevertheless the result is always to do its work, even if it be a very trifling performance, to thousands of pieces alike, so that the great desideratum of the production of interchangeable parts for movements of the same caliper is effected. While the system adopted affords practically a perfect interchangeability of the parts, yet it must be understood that the polishing and finishing of the parts leaves often microscopic differences which might be of importance in the case of fine movements. When therefore the parts of these watches are assembled, the exact sizes of the jewels are measured by means of the requisite gauges, the finest of which measures the seventeen-thousandth part of an inch. In this way systematic provision may be made for that freedom only in the operation of the parts of the movements which is essential to the proper performance of their functions under the conditions of temperature and other adventitious circumstances under which they are to operate.

Each watch of this character is numbered, and the exact sizes of all its pivots and jewels are accurately recorded. Hence, should any part of the watch fail, the factory can supply, upon receipt of the number of the movement, an exact duplicate of the required part.

The exhibit contained specimens of all the varieties of movements manufactured by this company. Of full plate movements there are seven distinct grades. These again are divided into varieties such as stem-winding and key-winding, or by varying the balance, making it in nickel, steel, gold, or bi-metallic of brass and steel for compensation, and also by varying the number of jewels. Of three-quarter plate movements there are four distinct grades, subdivided similarly into varieties. The total annual product of the factory is upwards of 100,000 watch movements and 50,000 silver watch-cases. The gold cases required are made by Messrs. Robbins & Appleton, in New York. The principal market for this product is in the United States, but already a considerable demand for these watches has been created and is now being supplied in England, Germany, and Russia. The value of the annual product of these two establishments exceeds $2,000,000.

In the examination of the quality of the watches produced by the American Watch Company, it became necessary to consider first the mechanical contrivances by which the parts are executed, and then the manner in which these are brought together in the completed movement. While introducing so much that is novel in the way of machinery and processes of execution, there has been no attempt, in respect to the parts of the movements, at innovations which are not of recognised merit. There are certain well established principles in reference to the proper construction of the train which have resulted from the application of the laws of mechanics, such as relate to the form of the teeth of the wheels, the leaves of the pinions, and the proper numbers for each. It is well established also, that for the purposes of a watch to be carried in the pocket, the lever escapement is to be preferred. The results of careful experiments show that when the lever escapement, the duplex escapement, and what is known as the chronometer escapement, are equally well constructed, and placed in movements with equally good trains and equally well sprung, the performance is substantially the same. There being, therefore, no objection to the lever escapement as regards the time-keeping properties, and there being good reasons for its adoption in preference to the two others named when the manner in which the watch is to be carried is considered, the propriety of this form of construction, even for the finest watches, is put beyond question. There is one innovation upon what was, in this country and in England, until recently regarded as an essential principle of watch construction, which the company ventured upon at the outset. This consisted in dispensing with the

fusee and chain, and using in preference the going-barrel, thus reducing very much the size and the complexity of the watch. The Swiss manufacturers long ago ventured, so to speak, to adopt to a considerable extent this form of construction, but the poor quality of the watches which the careless greed of manufacturers and importers flooded upon the markets of the world did much to strengthen the idea, among the dealers as well as among the purchasers, that a good watch must be provided with a fusee and chain, so that the ultimate force with which the power of the mainspring acted upon the escapement should be as nearly constant as possible. Hence the popularity of the English lever watches in this country, and hence the tenacity with which in England they still adhere to the notion that no reliance can be placed upon any other form of construction.

But wisely the pioneers in the introduction of this industry into our country decided to adopt the going-barrel, so as not only to reduce the size and expense of the watch, but also to obviate the great expenses for repairs made necessary by the frequent breaking of the chain. And besides, in the case of the breaking of the mainspring, the recoiling of the barrel, from the sudden removal of the pressure, creates the risk of injury to the teeth of the great wheel and to other important parts of the movement. Yet, in spite of these discouragements, the necessity of a fusee and chain seemed so apparent to those not versed in the knowledge of the action of the balance-spring as regulating the movement of the watch, that this notion, so well fortified, did much to oppose the introduction of the watches in which these parts were wanting. Certain it is that many scientific sceptics upon this point had to be convinced by actual trials before yielding their assent to the possibility of the construction of an accurate time-keeper upon the simpler system. It is indeed true that the force of the main-spring is not constant, but if the difference be not too great, the isochronal property of the hair-spring in proper or even approximate adjustment is quite sufficient to regulate the movement of the watch within the limits required. If the main-spring be of considerable length, and the number of turns when wound such that only comparatively a few turns are unwound during twenty-four hours, there will be very little variation of the force actually transmitted to the train, so that if the watch is wound regularly the small differences which would result are counteracted so completely by even an approximate isochronal adjustment of the balance-spring as to become practically insensible.

The safety of these simpler movements from any injury which might result from the breaking of the main-spring is most effectually provided for in all the watches made by this company by a device known as "Fogg's Patent Safety Pinion," invented in 1865. The arbour is tapped with a triple left-hand thread upon which the pinion screws. This pinion is toothed into the great wheel upon the barrel, and the action of the wheel upon it is in the direction of the tightening of the screw. Whenever, therefore, the mainspring breaks, the recoil of the great wheel unscrews the safety pinion from the arbour, and thus instantaneously releases the whole movement from the effect of the reaction.

It is well known that the teeth of the wheels should be epicycloidal in form, and the attempt is always made, in a properly constructed movement, to secure this form in the final process of finishing. Often, however, in the manufacture under the old system, partly on account of the difficulty of securing the proper form, and partly on account of the peculiar æsthetic notions of workmen who conceived a dislike to epicycloidal teeth because they had in mind the resemblance of their form to that of the bishops' mitres, this important principle was disregarded. Another obstacle arises from the difficulty of producing in miniature with precision what it is possible to draw only upon a magnified scale. But by the application of the machines constructed for this purpose, not only in this instance, but in many other similar cases in the production of the various parts, is the difficulty obviated, and the requirements of theory rendered possible in practice. The forms of the cutters and polishers of the machines which cut the gearing are kept true by means of a machine which gives the true epicycloidal form, so that by proper attention to the depthing when the train of wheel-work is put together in the watch movement, the perfection of smooth and continuous action is secured. It is right here that the superiority of the American system comes into important operation. While it is possible by the ordinary methods, by patient work, to produce the

wheels and pinions with the requisite degree of perfection, yet manifestly, on account of the necessary expense, this cannot be done in the case of the common grades. But by the method under consideration the action of the machines is precisely the same for all grades. There may be degrees of finish, but the form is unchanged, and the cheapest movements have this excellence in common with the best. The difference of the cost of watches not specially adjusted will therefore depend upon differences in the number of jewels, the finish of particular parts, and the character of the balance.

The excellence of the train being beyond question, the next and the important consideration is the character of the work in the construction of the parts connected with the escapement. These are all constructed by processes quite similar to those already mentioned, and hence attention may be directed particularly to the hair-spring and the balance. It is well known that it is upon the proper performance of these parts that the accurate time-keeping property of the movement depends. Any imperfection here will make manifest in a striking degree any imperfections in the train, and even when everything else is perfect, a failure here renders the movement practically worthless for the purpose for which it was intended. The balance-spring must be of the very best material, must be evenly coiled, and must be so tempered as to secure a maximum degree of elasticity, and a continuance of this quality undiminished. There will then be a relation between its elastic force, the length to be brought into action, and the weight of the balance which it is to control, to be determined so as to make the vibrations of this balance isochronous whether they be long or short. An examination of the process employed in springing the movements showed that this is accomplished by means of instrumental appliances with all the precision necessary, even in the case of the commonest grades of movements. For higher grades, not including those specially adjusted, to be considered hereafter, the process gives results of wonderful accuracy. The symmetry of the action of the spring, as its coils are caused successively to contract or expand, is carefully tested by an indicator constructed for that purpose, and the condition that the centre of torsion shall be coincident with the axis of the balance staff is thus secured in advance. The elastic force of the spring for different degrees of winding is next determined, and thereupon it is possible to select a balance from an assortment of compensated balances, prepared so as to fulfil the requirements for poise and compensation by identical processes, such that the conditions for isochronism are very approximately realised without any special adjustments after actual trials of the running movement. In this way movements which are of low price, and adapted to the general market, are produced which perform often equal to the most carefully adjusted. An actual trial, by timing tests of movements of this grade, has shown generally only small errors in the several adjustments for temperature, isochronism, and position, and in some instances they have been within the limits attainable by special attention to these adjustments in the usual way. Thus often, for a very moderate price indeed, may be obtained a movement of a very high order of excellence, such that if it had been adjusted by the usual method, on account of the attention required from the adjuster, its cost would have been necessarily increased tenfold.

The results of the examination of all the grades so far considered were, as stated in the report for an award, that for watches not specially adjusted, and including all the ordinary and medium grades as to price, this company is enabled to produce, in the case of such movements, better watches than are produced by the other methods in use, and that these products are worthy of special commendation.

This company also exhibited watches, the parts of which were also made by machinery and highly finished, and which had been specially adjusted for isochronism, for position of the balance, and for temperature. One of these, selected at random, was taken down, and all its parts minutely examined. The workmanship throughout was found to be excellent, and the materials the very best. The plates were of nickel, the wheels of gold. The holes were jewelled and capped, and the springs of excellent quality; and the balance-spring of the form known as the Breguet spring. The workmanship being of a quality to warrant a movement of the highest order, it remained to determine by actual trial the accuracy of the adjustments, and the regularity of the motions from day to day. The limited time available, in the course of the examinations, for a work of this kind, made it difficult to give to these

trials proper attention; but the requisite astronomical instruments being in position and available near the United States Government Building (being there as a part of the National exhibit), ten of these movements were taken from among those on exhibition, and subjected to trials. The first trials for errors of position were made for seven of these movements by Mr. Theodore Gribi, a member of the Swiss Commission, whose services as mechanical expert were of great value to the writer of this report in the course of the examinations in the department of horology. The trials made by Mr. Gribi were during days when the ranges of temperature were considerable, the average temperature in the building during the middle of the day often exceeding 100° Fahrenheit. The results of Mr. Gribi's comparisons during a period of ten days, as computed by him, are as shown by the following table:

No. of Watch.	Variation between				Sum of the Four Variations.
	Dial Up and Dial Down.	Pendant Up and Pendant Down.	Hanging and Lying.	Pendant Up and Pendant to Right.	
	s	s	s	s	s
670,087 -	2·36	8·35	0·11	3·77	14·59
670,061 -	1·40	1·50	2·65	3·23	8·78
670,082 -	0·73	0·98	0·30	0·01	2·02
670,083 -	1·76	0·44	7·01	5·01	14·22
670,092 -	0·88	7·31	3·18	5·19	16·56
670,044 -	3·74	1·45	0·28	0·46	5·93
Mean -	1·81	3·34	2·25	2·94	10·34

The numbers given show the difference of rate corresponding to a period of 24 hours.

The movement numbered 670,052, which was also compared by Mr. Gribi, is, for reasons which will subsequently appear, omitted from this table.

Subsequently, during the trial of the marine chronometers, these movements were subjected to further trials to determine their errors, and especially the errors of compensation for temperature. The results derived by the reporter from his observations in connection also with the comparisons made by Mr. Gribi, were communicated to the Centennial Commission in explanation of the award recommended by the Judges for the production by this company of first-class pocket chronometers. These results are as shown by the following table:

No. of Watch.	Variation for ±1° of Temperature.	Difference between Long and Short Arcs of Vibration.	Maximum Error of Position.
	s		
670,075 - -	±0·034		
670,099 - -	±0·188		
670,095 - -	±0·024	s	s
670,061 - -	±0·014	2·5	1·4
670,087 - -	±0·038	0·4	8·3
670,083 - -	±0·012	2·2	0·5
670,052 - -	±0·064	1·3	6·7
670,044 - -	±0·052	0·6	1·4
670,082 - -	±0·064	0·1	0·8
670,092 - -	±0·240	0·4	7·0
The mean of all gives	±0·07	1·07	3·7

These numbers refer to the variations of the rate corresponding to a period of 24 hours.

In the reduction of the observations for the movement numbered 670,052, included in the above table, it was assumed that an abnormal error, shown by Mr. Gribi's comparisons, was due to an error of observation, but subsequently it was found that the movement was not in proper running order, on account of clogging pieces of lint adhering to the escapement, and that it needed overhauling; and hence in the subsequent trials another movement was taken.

The results thus obtained were sufficient to show that the claim of the production of first-class pocket chronometers was well founded, and they served as the basis for the award to the company for that class of movements. Although sufficient to warrant the award made, it is true that they do not depend upon a series of observations sufficiently extended to be compared fully with the results of the trial of first-class pocket chronometers at the Swiss observatories where such trials are regularly made. And, besides, in the temperature trials there was some uncertainty as to the position in which the watches had been placed in the refrigerator during a portion of the 48 hours that they were kept in the cold. In order, then, to put the movements to a severer test, they were taken to the observatory at Ann Arbour, and there subjected by the reporter to a rigorous trial. The whole period of this final trial was eleven weeks, which is five weeks longer than the first-class pocket chronometers are tested at the Swiss observatories. The trial began on September 9, and ended on November 26, 1876, and the results for the successive weeks are shown by the table on page 843.

In these tables the watches are arranged in the order of their merit, as indicated by the range and fluctuations of the rate in all the changes of temperature from the beginning to the end of the trial; not taking into the account the errors arising from the change from the horizontal to the vertical position.

During the seventh week the watches were placed in different positions, with the dial up, in respect to the magnetic meridian, but no sensible errors which might be attributed to the action of magnetic forces were indicated.

In the ninth week of the trials the watches were kept during two days at a mean temperature of 36·7°, and then transferred to a warm room, in which they were kept for two days at a mean temperature of 95·1°.

During the tenth week the watches were kept three days with the dials down, in order to find the difference of rate between the dial up and the dial down.

By a comparison of the rates from day to day during the periods in which the position remained unchanged, the mean daily variation of the rate of each chronometer was obtained; and the variation of the rate, assumed to be uniform through a considerable range of temperature, corresponding to a variation of one degree of the thermometer, was derived by a comparison of the rates at the extremes of temperature to which they were subjected. In order to exhibit more fully the character of these movements the tables on pages 62 and 63 are subjoined, the numbers in which have been derived from the data obtained in the course of the final trials now under consideration.

Those who are familiar with investigations of this character will understand, without further explanation, what the numbers in these tables indicate; but for the purpose of making the results clear to the general reader, it is necessary to consider them more fully, commencing with that on page 844.

The mean daily rate, as shown in the second column, is the average rate by which each watch gained or lost on mean solar time during the whole period of the trials, and the next column shows the average temperature during the same period. The fourth column exhibits the mean variation of the rate from day to day, excluding the differences which resulted from the changes of position. The amount of this mean daily variation for a particular chronometer is a fair index of the perfection of its manufacture, except so far as relates to the special adjustments next to be considered.

In reference to the numbers given in the fifth column for the variation of the daily rate corresponding to a variation of one degree in the mean temperature, it should be stated that they represent this co-efficient as derived from the differences corresponding to a range of temperature from 36·7° to 95·1° Fahrenheit, disregarding the effect due to the irrationality of the compensation, for which, in marine chronometers, a secondary or auxiliary compensation is frequently applied to the balance. In reducing the rates to a mean temperature,

TABLE

Showing the Performance of the Watches during a Trial of Eleven Weeks.

Week of Trial.	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.
Range of Temperature -	57° to 69°	60° to 72°	47° to 69°	43° to 53°	35° to 50°	39° to 66°	40° to 61°	49° to 65°	31° to 99°	40° to 77°	55° to 69°
Mean Temperature - -	62·1°	66·5°	53·1°	48·7°	43·4°	54·8°	48·8°	56·3°	61·8°	52·7°	61·4°
Position - - - -	Horizontal. Dial up.	Horizontal. Dial up.	Vertical. Pendant up.	Vertical. Pend. down.	Vertical. Pend. right.	Vertical. Pend. left.	Horizontal. Dial up.	Horizontal. Dial up.	Horizontal. Dial up.	Horizontal. Dial up & d'n.	Horizontal. Dial up.
Number of the Chronometer.	WEEKLY SUMS OF RATES.										
	s	s	s	s	s	s	s	s	s	s	s
670,044 - -	− 5·65	− 4·80	+27·55	+52·10	+42·05	+18·20	+ 2·05	− 3·50	+ 1·40	+11·35	− 5·55
670,089 - -	+ 3·05	+ 3·35	+47·40	+70·60	+114·85	+66·85	+11·90	+13·50	+12·65	+ 6·40	+10·05
670,082 - -	−13·65	− 7·60	+ 9·10	+15·85	+ 9·65	−10·25	− 7·90	−11·30	−11·30	−16·75	−21·95
670,095 - -	−20·85	−16·95	−18·15	+ 7·85	+ 1·40	+25·75	−20·90	−16·50	− 8·55	−18·90	−20·00
670,087 - -	−14·15	−17·20	+ 6·35	+79·20	+67·40	− 1·95	− 8·45	−14·35	− 3·55	− 9·50	−18·85
670,083 - -	+ 1·70	+ 7·80	+ 5·15	+57·60	+71·95	+42·45	+19·05	+27·95	+23·40	+10·20	+18·20
670,090 - -	+ 7·45	+ 6·45	+36·55	+27·30	+42·50	− 1·75	+24·90	+17·80	+29·45	+34·00	+29·80
670,061 - -	−27·70	−39·50	+ 1·25	−20·95	−45·80	−32·50	−47·60	−49·40	−35·70	−36·05	−55·45
670,099 - -	−20·25	−26·15	+20·20	+66·15	+69·85	+53·25	− 6·25	−18·05	−10·50	− 0·35	−22·65
670,092 - -	−15·90	−11·35	−59·43	−31·62	−63·05	−62·15	−32·45	−31·55	− 9·30	−22·35	− 7·20

These watches are all stem-winders. The duration of the trial in each position was such as to indicate unmistakeably the total effect of irregularities of motion due to the change of position, and through considerable changes of temperature.

TABLE

Showing the Mean Daily Rate and the Mean Daily Variation of the Rate, corresponding to a Period of Twenty-four Hours, in Different Positions, &c.

Number of the Chronometer.	Mean Daily Rate.	Mean Temperature.	Mean Daily Variation.	Mean Variation for ±1°.	Before and after Oven.	Difference between Hanging and Lying.	Difference Hanging and Pendant Left.	Difference Hanging and Pendant Right.	Difference Dial Up and Dial Down.	Sum of these Four Variations.
	s.	°	s	s	s	s	s	s	s	s
670,090 - -	+2·76	59·5	±0·12	∓0·098	0·0	−2·98	−5·30	−0·11	−1·30	9·69
670,089 - - -	+1·15	,,	0·14	∓0·038	0·5	−5·75	+2·71	+9·25	−1·77	19·48
670,082 - -	−1·75	,,	0·20	∓0·041	0·0	−1·83	−2·69	−0·31	−1·55	6·38
670,095 - - -	−2·47	,,	0·21	∓0·014	0·7	+0·26	+6·23	+2·53	+0·10	9·12
670,083 - -	+2·34	,,	0·26	∓0·089	0·5	+1·27	+5·48	+8·67	−3·25	18·67
670,044 - - -	−0·38	,,	±0·27	∓0·094	0·2	−3·28	−1·16	+1·10	+3·85	9·39
670,092 - -	−2·57	,,	0·30	±0·214	0·7	+3·91	−0·74	+1·52	−1·25	7·42
670,087 - - -	−1·82	,,	0·31	∓0·005	0·1	−2·69	−1·13	+8·23	−0·20	12·25
670,099 - -	−2·47	,,	0·39	∓0·164	0·3	−4·34	+5·01	+5·44	−0·37	15·16
670,061 - - -	−6·08	,,	0·54	∓0·014	0·4	−4·63	−4·75	−6·87	+0·45	16·70
Mean of all - -	±2·38	59·5	±0·27	±0·077	0·3	±3·09	±3·52	±4·40	± 1·41	12·42

In this table the watches are arranged in the order of their mean daily variations of rate.

In trials of this character, one of the conditions of competition often imposed in advance is that the difference between hanging and lying shall not exceed a certain limit, and a result has been an attempt to accomplish this at the sacrifice of the adjustments in other positions. The movements under consideration were not adjusted specially in reference to any such condition.

TABLE

Showing the Mean Daily Rate in Different Weeks, and the Variations of Rate for Changes of Position.

Number of the Chronometer.	Difference Pendant Up and Pendant Down.	Difference Pendant Right and Left.	Difference of Rate between First and Eleventh Weeks.	Difference before and after Vertical Positions.	Mean Daily Rate for Weeks in which Position was Horizontal. For Temperature 60° Fahr.						
					Before Exposure to Heat.				After Exposure to Heat.		
					First.	Second	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.
	■	■	s	s	s	s	s	s	s	s	s
670,090 -	−1·76	−5·18	+3·19	+0·87	+1·26	+1·56	+2·44	+2·17	+4·39	+4·68	+4·44
670,089 -	+3·14	−6·40	+1·00	+0·51	+0·50	+0·74	+1·25	+1·78	+1·74	+1·38	+1·49
670,082 -	+0·79	−2·38	−1·19	−0·74	−1·87	−0·83	−1·58	−1·77	−1·54	−2·02	−3·07
670,095 -	+3·65	+3·64	+0·12	−0·81	−2·95	−2·33	−3·13	−2·31	−1·20	−2·85	−2·84
670,083 -	+7·09	−3·19	+2·36	+0·01	+0·44	+1·69	+1·71	+3·66	+3·50	+2·35	+2·72
670,044 -	+3·06	−2·27	+0·01	−0·61	−0·63	−0·12	−0·72	−0·83	+0·37	−0·71	−0·66
670,092 -	+4·94	−2·30	+1·24	+0·53	−2·73	−3·04	−2·48	−3·69	−1·74	−1·23	−1·33
670,087 -	+9·94	−9·33	−0·67	−0·18	−1·85	−1·92	−2·10	−2·35	−0·37	−1·93	−2·58
670,099 -	+5·81	−0·43	−0·34	−0·06	−2·54	−2·67	−2·74	−3·21	−1·22	−1·45	−2·99
670,061 -	−3·23	+2·09	−3·96	−1·40	−3·93	−5·55	−6·96	−7·11	−5·08	−5·45	−7·90
Mean of all	±4·34	±3·72	±1·41	±0·57	±1·87	±2·04	±2·51	±2·89	±2·12	±2·40	±3·00

In this tablethe watches are arranged in the order of their mean daily variation of rate.

The means given at the bottom show the average accuracy of the performance of the whole group.

when such reductions were required, a small correction was introduced on thi account, whenever its amount was clearly indicated by the observations.

The numbers given in the column headed "before and after the oven," exhibit the change of the daily rate found by comparing the rates on the days preceding and following the placing of the watches in a heated room, and show how far they are affected by sudden and violent changes of temperature.

In order to understand the significance of the numbers in the succeeding columns, which relate to the differences due to changes of position, it is necessary to call attention again to the character of the final adjustments of a first-class pocket chronometer. The general nature of these adjustments, and the methods by which they are approximated to by this company in the case of even the cheaper grades of movements, have already been alluded to, but for our present purpose further consideration of this subject will not be out of place.

The parts of the escapement being supposed to be of proper construction and in proper adjustment in the movement, the attention will finally be directed to the balance and to its controlling spring. In reference to the balance, it is often erroneously supposed that the office of the compensation by means of a bi-metallic segmental rim of brass and steel is to counteract simply the effect of the expansion of the balance itself by an increase of temperature, whereas in fact the change of rate arising from the loss of the elastic force of the balance-spring, by an increase of temperature, is five times greater than that resulting from the expansion of the balance. And still further, there is a change of rate due to the elongation of the spring from the same cause. The compensation of the balance must provide for all these changes, and they amount to a change of the rate to the extent of more than one minute in twenty-four hours for a change of only ten degrees in the temperature. This, however, is now so well understood, that within limits which are always possible to good workmanship the compensation can be readily effected, and the poise of the balance with reference to the axis of its staff successfully arranged. But when the attention is finally directed to the adjustment of the balance-spring, the difficulties to be encountered require the highest knowledge and the most skilful manipulation on the part of the adjuster. On account of the change in the amount of the friction in different positions, and on account also of different degrees of viscosity of the oil at different times, and on account, further, of inequalities of motion communicated by the train, the arcs through which the balance will vibrate will be subject to considerable fluctuations even under the most favourable circumstances. When we add to these the interferences which are constantly operating as the watch is carried about in the pocket of the wearer, it becomes of the highest importance that the isochronism of the spring shall be as perfect as possible. The property of an isochronal adjustment, it is well known, is that the vibrations of the balance shall be performed in the same time whether they be long or short. This will require, in general, for a balance of a given weight and diameter, a certain determinate length of the spring in action, and a form such that this action shall be symmetrical in reference to the motion of the balance each way from the point of quiescence. When this adjustment is once secured, it is evident that any change of the acting length of the spring will destroy this important provision; and here comes in one of the difficulties in the adjustment of a pocket chronometer which is to be carried in different positions. In the case of a marine chronometer, there is provision made that the instrument shall perform its functions always in the same position, and hence, when the balance is once poised, regulated to time, and the isochronal adjustment of the balance-spring completed by comparing the times of vibration, or the daily rate, in long and short arcs, obtained by varying the acting power of the mainspring, the desired result is accomplished. But in the case of a watch, even if the poise be perfect, the isochronal adjustment made perfect for a horizontal position will be found to be in error in other positions, because of the modification of the action of the spring as its position is changed. It becomes a very difficult matter, therefore, to secure the perfection of the adjustments for a variety of positions when an extreme limit of precision is sought. It has already been mentioned how these adjustments are by instrumental appliances effected in all the watches made by this company, when once the required relation of the parts has been established; but the production of movements of the highest degree of excellence requires that further and special adjustments be made.

The elastic force of the spring as its coils are contracted or expanded from the state of quiescence, must change its value in a ratio depending upon the weight and diameter of the balance, for the case of isochronal action, and this relation is found by careful trials. The weight of the balance is not affected by the temperature, but its diameter is thus changed, and here again a source of error creeps in. It is the accumulation of all these errors, infinitesimal almost in each vibration, which, in the course of the twenty-four hours, gives a finite error in excess or defect, and thus alters the rate of the watch. If the acting part of the spring be too short, the tension as it is wound will be too great, and in the course of long arcs of vibration the rate will gain, while in short arcs it will lose. But if the acting part be too long, the tension due to the elastic force will be too small, and the watch will lose during the long arcs of vibration and gain in the case of the short arcs. Any bend in the spring changes the effective length in action, and hence the final isochronal adjustments are effected by modifying the terminal curves of the spring without unpinning it from the collet or the stud.

It is evident, further, that when once these adjustments are effected, it is of the greatest consequence that the conditions remain unchanged. Hence the importance of a spring properly and permanently tempered. It has been established by experiment that the effect of the process of tempering the spring is to leave it, before it has been put into use, in a condition such that the relations of its molecules do not become permanent until it has been for some time in continuous vibratory motion, and further, that the effect of such motion is to produce in the outset an increase of its strength and elasticity, and hence an acceleration of the rate of the movement which it controls.

The use of the flat spring in these chronometers requires that, for the best and most permanent adjustment, a terminal curve for the spring be brought out of and over the plane of its coils. This is not essential for a spring whose action shall be always in the same position, but when the positions are to be different the form of this terminal curve performs an important office in the adjustment. Sometimes both ends of the spring are turned into such terminal curves, and theoretically there would seem to be good reason for this arrangement; but the difficulties of finding, in practice, the proper forms for two such terminal curves is a sufficient warrant for confining the attention to a single curve, as in the Breguet form of the spring adopted in the construction of the watches under consideration.

The accuracy of the adjustments depending upon the positions in which the watches where placed is sufficiently indicated in the several colums of the tables. A reference to the table showing the weekly sums of the rates will indicate the time allotted in the trials to each position in which the movements were tried. It will be observed that the periods were such as to make prominent the irregularities depending upon these changes of position, and further, that the trials extended to six positions, besides tests for the influence of possible magnetic action. It is hardly necessary to add that the tables establish conclusively the excellence of all the adjustments. And it should be borne in mind, in a just determination of the merits of these movements, that they were subjected to great vicissitudes before they received the long trial of eleven weeks. They had been taken from the factory to the Exhibition before its commencement. They were not regularly wound and kept running, but only so kept during the progress of three distinct trials separated by considerable intervals, and they were exposed to great changes of temperature. After the partial trials at Philadelphia they were allowed to remain unwound and at rest, then they were again wound and started, carried to Ann Arbor, and, after an allowance of only three days to assume their regular rate, the final trials began. These extended over the long period of eleven weeks, and through considerable ranges of climatic temperature, circumstances such as to test severely their running qualities. In order to do full justice to the exhibit, it would have been better to extend the trials to a much larger number of movements, because in the case of so small a number involved in the means taken, a single watch going badly, or not very closely adjusted for errors of temperature and position, affects the mean results much more than if the number were greater. The limitation of the number was not the fault of the exhibitors, but was determined by the convenience of the reporter, who could not undertake, in con-

nexion with the other duties devolving upon him, the trial of a greater number.

It would be of benefit to the company if their finest productions could be subjected to trial every year in some astronomical observatory. Nothing has done more to stimulate the Swiss manufacture towards excellent workmanship and the most careful adjustments possible than the competitive trials which have been made for a series of years at the observatories at Neuchâtel and Geneva. In this way, by comparison of results, can some idea be formed of the progress made and the degree of perfection attained. The trials of the first-class pocket chronometers at the Swiss observatories extend over a period of six weeks. They are tried in five positions and in the oven. The second grade of pocket chronometers are subjected to trial for four weeks, in two positions, hanging and lying, and in the oven. It will be seen by reference to the parts of this report which refer to the English, Swiss, and German exhibits, that the labours of the Judges were very much facilitated by the certificates issued from the observatories, showing the results of the actual trials of the adjusted movements which were on exhibition. And in a determination of the progress which has been made in America, there was thus provided a standard of acknowledged excellence. It is not the purpose of this report to make direct comparisons of the productions of different manufacturers. The reader who is curious in such matters will find, in most cases, the requisite data under the heads of the report relating to the exhibits in question. But in order to convey to the general reader an idea of what the system of manufacture under consideration has made possible in a newly-developed industry in this country, it is proper to state here that the reporter has compared the results of the trials as heretofore given with those furnished for all the first-class fully-adjusted watches in the International Exhibition, and that it is clear beyond question that the chronometers numbered 670,044, 670,082, and 670,095 are altogether superior to any others exhibited. The tables already given show clearly the excellence of their adjustments, and the smallness of the mean daily variation of their rates. The best of these, taking everything into account, is No. 670,044, for which the mean daily rate was only thirty-eight one-hundredths of a second, and for which the difference of mean daily rate between the first and eleventh weeks of the trial was only one-hundredth of a second. The steadiness of the rates of these watches is best shown by placing in juxtaposition the average daily rate during several weeks separated by considerable intervals, and during which the determining conditions were very different as already stated. The following are the results:

Week ending		Mean daily rate of No. 670,044.	No. 670,095.	No. 670,082.
		s	s	s
1876.	July 20	—0·50	—3·60	—2·80
	Sept. 18	—0·63	—2·95	—1·87
	Oct. 30	—0·72	—3·13	—1·77
	Nov. 26	—0·66	—2·84	—3·07

These numbers, for the sake of comparison, are reduced as nearly as possible to the temperature 60° Fahrenheit.

The performance of No. 670,044 is extraordinary, considering the vicissitudes to which is was subjected and the long period of nineteen weeks during which its rate is considered. The mean daily variation of the rate is greater than that of each of the other two, but this may be due to the imperfect elimination of the error of the eccentricity of the second's dial in the daily comparisons. Its temperature correction is also apparently somewhat larger, but that all the essentials for good performance were present is best attested by the steadiness of the rate from week to week as it was under trial.

No. 670,089 is hardly of inferior rank to the three here specially mentioned, although the sum of its position errors is greater than the general average.

The results thus developed show clearly enough that there is no lack in this county of mechanics skilled in the most abstruse principles of horology, and able to execute their work in accordance therewith. But it is a lamentable fact that the great majority of those who are to care for these productions after they are put into use are in total ignorance of the fundamental principals upon which the performance of a watch depends. It would be of inestimable benefit to the public, from an economic point of view, if there could be established in this country schools of horology, where young men desiring to become experts in the repairing even of watches could be enabled to acquire that knowledge and experience which is essential to the proper performance of this kind of work. In every industrial or intellectual pursuit in life it is desirable that men should be thoroughly educated in the principles underlying their profession, and in none more so than in that which we are considering, It is true that we find occasionally men in this profession also imbued with the desire to know the why and the wherefore, who have sought to acquire, and often have acquired, such education; but too often indeed do we find men professing to be accomplished watch-repairers who are in profound ignorance of the principles upon which the peculiar functions of these instruments are correctly performed, and who are liable to undo in a moment what has been achieved by the patience and skill of an accomplished manufacturer. The reader will already have in mind, from what has been under special consideration, that the greatest care is necessary in respect to fully-adjusted watches. For needed repairs they should be intrusted to men who fully understand that the relations of the balance and the hair-spring should never be disturbed, even to the minutest bending or lengthening of the spring, or disturbance of the weights of the balance.

It is apparent, therefore, how important it is to the possessor of a good watch that it shall not be liable to be ruined by the ignorant manipulation of some professed watch-repairer who undertakes to clean it. The desire to regulate such a watch to run in conformity with a worthless clock, with pretended compensation of the pendulum, has often been the source of mischief to the machine which should regulate instead of being regulated. And further, it should be borne in mind that the use of watches has now become so general that the expenses of cleaning and repairs must amount to millions of dollars annually. These expenditures result partly from necessity, partly from the worthlessness of movements palmed off by irresponsible dealers upon a confiding public, and partly from the ignorance of those who undertake the repairs. It is one of the merits of the system of watch-manfacture under consideration, that is reduces to a minimum the expenses to be incurred and the dangers to be encountered.

The general reader, unacquainted with the results which are obtained from clocks and chronometers of the best construction by those who are concerned with the accurate determination of time, may perhaps expect closer results than those indicated in the fore-going tables, especially when recalling to mind some of the extravagant statements often made as to the running qualities of watches in the hands of wearers whose comparisons have been made at long intervals, and often with uncertain standards, thus obtaining accidental coincidences. The trial of the movement from day to day, with exact standards of comparison, will necessarily reveal those errors which are compensated or concealed when the intervals of comparison are very long.

The fulness of this report on this particular exhibit has been made necessary on account of the disposition manifested by certain foreign manufacturers to arrogate to themselves and their country the sole possession of that knowledge and skill which can render possible the higher achievements of horological art. While conceding, as they have been compelled to do, by the inexorable logic of the facts before them and the world, the superiority of the American system of manufacture in the case of all but the specially adjusted watches, they have been disposed to cling to the latter as of their exclusive control, and to look with suspicion upon any results which go to show the possibility of excellent production in these higher grades also. The final adjustment of a watch for position, for isochronism, and for temperature, requires only that the maker shall be able to produce the best quality of springs, of the desired form, and to make a balance of proper proportions, it being supposed that the escapement and the train have been properly constructed. The adjuster must understand

the methods of springing, must know how to secure the poise of the balance and how to modify the acting part of the spring so as to secure isochronal action in different positions and at different temperatures. It cannot be supposed that the science and skill which have achieved wonders in all of what might be called the inferior operations should find an insurmountable barrier here. The results of the trials of the very few watches selected for that purpose from among those of the exhibit under consideration, show that such is not the case. And the manufacturers may claim superiority for their finest productions, for the very simple reason that the machine to be adjusted finally for all the errors which interfere with accurate time keeping is a better machine when constructed upon their system that when constructed upon the old system, and the better machine being equally well adjusted with the inferior one, in respect to these isochronal functions, must, in the nature of things, be of a perfection more enduring, and must satisfy better all the conditions for the highest productions of horological art.

Elgin National Watch Company, Elgin, Ill.

A collection of movements representing the different grades of their manufacture, but, for reasons which were not stated, these were not entered for competition for an award. The methods of construction adopted by this company are, in many respects, analogous to those employed by the American Watch Company, and already described. The Western Company, in fact, had its origin in the emigration to the West of a considerable number of the skilled employés of the Waltham Company, and so far as not protected by patents, the methods in use at Waltham were put into operation at Elgin. The Elgin company was organized in 1864, and at once commenced the manufacture of the necessary machinery for the production of watches upon the American system. In 1867, the first watches were made and put into the trade, and from that time forward this company has been engaged in an extensive manufacture, ranking next to the American Watch Company in the amount of its annual productions. The factory, which gives employment to about seven hundred persons, is located at Elgin, Illinois, about forty miles west of Chicago. It is supplied with every equipment necessary for its work. All the varieties of movements required by the trade are constructed by this company, with the exception of fully adjusted movements, which have only been made in particular instances, and not for sale to the trade. It is understood to be the intention of the managers of this company to commence the manufacture of the highest grade of movements also. At present they manufacture five distinct grades of full plate movements, and three grades of three-quarter plate movements. These are subdivided into varieties in the usual manner, according to the number and quality of the jewels, the form of the balance, or the mode of winding. The best movements are adjusted for temperature and approximately for position. The parts of each grade are made interchangeable to the limit regarded as practical and economical. For protection of the movements against injury resulting from the breaking of the mainspring, they are provided with a safety pinion, not so good under all circumstances as Fogg's, but still sufficient for the purposes intended. The pinion is clamped to the arbour of the centre wheel by means of a nut screwed upon the same arbour, which is promptly unscrewed by the force of the reaction in case the mainspring breaks, thus unclamping the pinion and leaving it free. All the movements which are full jewelled are adjusted for temperature by trial.

Since the movements exhibited by this company were not in competition for an award, they were not subjected by the Judges to any critical tests as to their running qualities as instruments of precision. The reporter has, however, at various times subjected watches made by this company to trials for steadiness of rate, and the results have been satisfactory. In one instance one of their best movements, which had been carefully adjusted, but which had the ordinary flat, spiral balance spring, was used upon an eclipse expedition to Sicily, in 1870, in preference to a first class pocket chronometer by Frodsham, for the service for which a pocket chronometer was needed, for the reason that it was found to maintain a steadier rate, when carried about, than the chronometer mentioned.

Empire City Watch Company, Jersey City, N.J.

A collection of watch movements and parts of movements, constructed at their factory. There was no person in attendance to give any information in reference to this factory, and the movements on exhibition appeared to be indifferently executed, and by no means creditable to the present state of the watch making industry in the United States.

Julius Elson, Boston, Mass.

A new form of watch regulator patented by him. Its acts in the nature of a compound lever, and will undoubtedly answer well for the purpose of its construction.

Hietel Brothers, Philadelphia, Pa.

An improvement in the fork of a lever escapement converting it into a spring bar in such a manner as to prevent the breaking of the roller pin, or its excessive rebounding when the balance has received a violent shock.

English Watches.

The conservatism of most of the English watchmakers, in resisting the innovations and improvements of later times, has resulted in a steady decline of the watch making industry in Great Britain, and especially for export to other countries. The old fashioned, clumsy English lever watches, with fusee and chain, are still made and sold in considerable quantities for home demand, but they have long since ceased to be sent abroad as in olden times. It must not be supposed, however, that the best manufacturers do not continue to produce the finest specimens of their art. Nearly all of the manufacturers of marine chronometers devote attention also to pocket chronometers. The latter are often constructed with the same care as their marine chronometers, and are fully adjusted for the errors of temperature and position. In respect to these there has been no decadence of the industry, but it has been in reference to the common grades of movements intended for the purposes of commerce. Numerous specimens of the better class of English movements were shown at the Exhibition.

M. F. Dent, London.

In addition to the marine chronometers already mentioned, Mr. Dent exhibited pocket chronometers, repeating watches, and stop or timing watches, of ordinary size, and of excellent workmanship throughout. The balance springs were in some cases the flat spiral, with a single terminal curve above. In others, they were provided with cylindrical springs, terminating in a flat spiral below, or in some instances, in two flat spirals, one above and the other below. The former is known as the "duo in uno," and the latter the "tria in uno" balance spring. The use of these forms of balance springs is believed by the makers to facilitate the adjustments for isochronism and position, and doubtless such is the case; but whether the performance is any better than in the case of a flat spiral, with the proper terminal curves, when once the proper adjustments are effected, remains to be determined by an extended series of trials, and the reporter has no knowledge of any such having been made.

Charles Frodsham & Co., London.

An exhibit, in connexion with their clocks and marine chronometers, of pocket chronometers of varied forms, all finely executed. The springing, in particular, appeared to be excellently done, so far as could be determined without an actual trial, for which the movements were not submitted. There were also repeaters, of which the repeating mechanism had been made in Switzerland, and the movement adapted to it at their establishment in London. One of the pocket chronomoters had a "duo in uno" balance-spring, which had been designed by the late Charles Frodsham as long ago as 1852.

Nicole, Neilson, & Co., London.

A collection of pocket chronometers, and sporting, calendar, and repeating watches, manufactured by them. Their watches showed signs of good workmanship, and the number and variety of the specimens exhibited were such as to indicate that in respect to complicated watches they are rivals of the most extensive manufacturers of these in Switzerland. In most cases the English

makers import the parts of the mechanism of the complicated movements from Switzerland, and simply adapt the English time-movement to them; but the reporter was assured that Messrs. Nicole, Nielson, & Co. manufacture every part. Their arrangement for stem-winding is simple and effective. There is no arbour running into the case, but attached to the stem is a wheel working into a conical pinion, which gears into another wheel acting upon the barrel. The conical wheel is held by a bridge, which also fixes the movement in the case, so that by taking off the bridge the movement is at once released from the case. They exhibited also calendar watches, of various styles, and all apparently well executed. In some of the complicated watches a dial was provided on the front and on the back, which arrangement appears to be especially convenient in the case of some kinds of complicated watches.

J. Sewill, Liverpool.

A display, in connexion with his marine chronometers, of several fine watches, which were stated to have been adjusted for the errors of temperature and position, although no results of trials were shown. There were also several complicated watches, as well as a collection of the ordinary English lever watches.

Victor Kullberg, London.

Pocket chronometers, made with the same care as his marine chronometers. These had shorter detent springs than usual, and so placed as to be in a vertical position when the watch is hanging. His stem-winders can only be wound when opened, and there is an indicator to show when the spring is wound up.

James Poole & Co., London.

The marine chronometers of this firm were the only ones submitted for actual trial by English makers. They also exhibited several well-finished watch movements. They were not subjected to any timing tests, but so far as could be otherwise determined, they appeared to be well sprung. Generally they had flat spiral balance-springs, with a single terminal coil above. One had a cylindrical spring, and had been carefully adjusted for temperature and isochronism. The workmanship was quite in accordance with what might be expected after an examination of the excellent marine chronometers constructed by him.

French Watches.

The manufacture of watches has been an important industry in France since the earliest production of these instruments, and the history of watch-making in that country is, indeed, so closely related to that in Switzerland, that it would be difficult to draw a dividing line. In many cases, a century ago, the most famous makers in Paris had a great part of the work actually done in Switzerland, and the same is true to-day. At Besançon, however, there is an extensive manufacture of watches, and the result has been a corresponding diminution of the imports of Swiss watches and parts of watches into France. The French watches shown at the Exhibition were ostensibly by Paris makers, but an examination showed that they were in most cases of Swiss manufacture. The houses which exhibited were: B. Haas, Jr., & Co., Paris; Bréguet & Co., Paris; and J. B. Gondy & Co., Pontarlier. The watches were noticeable chiefly on account of the elegant decoration of the cases. There were simple and also complicated movements, but of ordinary quality, without any novelties requiring special mention. The name of Bréguet is justly celebrated in the history of horology, but, in the present instance, it is used in connexion with movements actually made in Switzerland to enhance their value in the eyes of purchasers.

Watch-springs of excellent quality were exhibited by Hangard, of Paris, and Eugéne Moat, of Revigny.

German Watches.

Watch-making in Germany has never reached that extent of manufacture which it has in some other countries; nevertheless, excellent movements have come from German workshops. Of late the quantity of the productions has considerably increased. Some excellent specimens of German manufacture were shown at the Exhibition.

Messrs. A. Lange & Sons, Glashütte, Saxony, have established a reputation for the production of good pocket chronometers, and several specimens of their best work were on exhibition. There was also shown a working model of the lever-escapement which they employ. The acting surfaces of the pallets are curved so as to secure uniformity of action during the communication of the impulse. The finish of the parts was good, and the movements were well sprung. They were provided with trial-certificates, made at the Leipsic Observatory, under the direction of Professor Bruhns. The trials extended over four weeks, and the results are as shown by the following:

Week of Trial.	No. 10,732.			No. 10,733.		
	Position.	Temperature, Centigrade.	Mean Daily Rate.	Position.	Temperature, Centigrade.	Mean Daily Rate.
			s			s
First -	Lying.	+ 23°	− 0·48	Lying.	+ 23°	+ 2·18
Second -	Carried and lying.	+ 32° to + 18°	+ 1·68	Hanging.	+ 24° to + 18°	− 3·94
Third -	Hanging.	+ 18°	− 1·05	Carried and lying.	+ 32° to + 18°	− 1·56
Fourth -	Lying.	+ 20°	− 0·90	Lying.	+ 20°	+ 1·43

Week of Trial.	No. 10,926.			No. 10,927.		
	Position.	Temperature, Centigrade.	Mean Daily Rate.	Position.	Temperature, Centigrade.	Mean Daily Rate.
			s			s
First -	Lying.	+ 17°	− 0·63	Carried and lying.	+ 30° to 12°	− 0·10
Second -	Hanging.	+ 18°	+ 1·76	Lying.	+ 18°	+ 0·15
Third -	Carried and lying.	+ 30° to + 12°	− 2·30	Hanging.	+ 18°	− 1·61
Fourth -	Lying.	+ 15°	− 0·12	Carried and lying.	+ 30° to + 12°	− 0·50

The observations were not sufficiently extended to show the error of compensation for temperature, nor to show very satisfactorily the mean daily variation of the rate. During the weeks when the positions indicated are "carried and lying," the watches were carried in the pocket of the observer during the day, and during the night they were placed horizontal, dial up.

The Vereinigte Uhrmacher, Glashütte, Saxony, is an association of watch-makers, the members of which work singly in the production of particular parts, but bring together their several productions for the market. They furnish movements and parts of movements, and a collection of specimens of their work, of various grades, was shown at the Exhibition. The execution of the several parts appeared to be good, and while not showing any special merit, was yet sufficient to indicate that the association has, among its members, excellent workmen.

Swiss Watches.

The Swiss have been famous as watch-makers for nearly two centuries, and some of the most remarkable specimens of watch-work have come from that country. The system developed has been that of the minutest division of labour; individuals and families devoting their attention to the production of particular parts. It is said that a Swiss complicated watch, in general, passes through the hands of one hundred and thirty different workmen before it is put upon the market. The system of work by families scattered about in the country, as well as in the cities and villages, reduced the cost to a minimum in a country where wages were low. Besides, the minute division of labour made the acquisition of many parts of the trade comparatively easy, so that the result has been a rapid increase of the number of workmen, and too often a corresponding deterioration of the quality of their productions,—particularly so in reference to the lower grades of watches. For the finer specimens of

work the production has been confined to a limited number of skilled artists, so that, in times past, it might have heen said that while Switzerland supplied the poorest watches she also supplied the best.

The number of persons actually engaged in the watch-making industry in that country is estimated at 40,000, representing a population of 150,000 persons. The total number of watches produced annually has been enormous, sometimes reaching 1,600,000 completed movements, and the market has been found in almost every country of the globe. Besides the competed movements, they have supplied watch-makers of other countries with parts of movements. The United States have furnished customers in abundance for watches of every grade, from the poorest to the best. The importations of these watches were approximately as shown by the following:

Year.	Number.	Year.	Number.
1864	169,000	1870	330,000
1865	226,000	1871	342,000
1866	262,000	1872	366,000
1867	207,000	1873	204,000
1868	209,000	1874	187,000
1869	206,000	1875	134,000

Among these importations were quantities of the very poorest specimens of Swiss production, and the sale of these by unscrupulous dealers has reacted seriously to the injury of their whole trade. In many parts of the country, on account of the impostures thus perpetrated, the very name of a Swiss watch began to be indicative of its worthless character. Proceedings of this kind undoubtedly aided in the introduction of the products of home manufacture, and the excellence of the common grades of American watches in comparison with Swiss watches of corresponding prices being well known, did much to strengthen the confidence of purchasers of watches of a higher grade; and thus was stimulated and rewarded the production in the United States of fine watches as well as cheaper ones.

The rapid diminution of late in the number of watches annually imported from Switzerland into the United States is shown by the foregoing tabular statement, and the diminution there shown has continued in undiminished ratio. This falling off in the demand had seriously disturbed the business in Switzerland, but it was attributed to the general depression of business, and it was not until the International Exhibition at Philadelphia that it came forcibly to the knowledge of the Swiss manufacturers that the competition of the American factories was the real cause of their misfortunes. It has already been shown in this report that the application of the American system of labour-saving machinery to the manufacture of watches has overcome the commercial difficulty arising from the difference of wages in the two countries, while the production of interchangeable parts, and the uniformity and accuracy of their production, have established the character of the watches as accurate time-keepers, so that the lost trade can never be regained. The exportations to the United States having been for many years nearly, if not quite, one quarter of the entire Swiss production, the crisis produced by the new rival in manufacture has been and continues to be a very serious one. The only solution which has been proposed as capable of furnishing a favourable result has been the introduction of the American system of manufacture into that country, where there are already so many skilled horologists and mechanicians. But the further difficulty to be encountered will be that which results from the conservatism of the people in opposition to all innovations. Capital is not wanting, and the skill of the artizans is unquestioned; but the sense of freedom inwoven by the system in vogue for centuries will make it difficult, if not impossible, to introduce the American system, according to which, while there is a minute division of labour, the whole work is done in a single establishment. Besides, too, in respect to the cheapness of production, the disparity of wages does not enter as so important a factor when the system of production by machinery is in competition in each case. While it is true that the application of labour-saving machines has been extensively introduced into watch manufacturing in Switzerland, yet it must be understood that these are of a very different character from those already mentioned in connexion with the American system of manufacture.

The achievements in horology, and especially in the adjustment of watches as real instruments of precision, which have established the peculiar skill of the Swiss, have been due largely to the fostering care of the Government, which has provided astronomical observatories for the principal object of testing the adjustments of the best watches produced, and which, for many years, has stimulated the manufacturers to a generous rivalry by the establishment, in connexion with the observatory trials, of competitive awards of prizes. These prizes have been sought, not for their intrinsic value, but rather for the distinction which they conferred. In addition to these trials, schools of horology have been established and fostered, where not only the requisite mechanical operations were taught, but where the knowledge of geometry, trigonometry, descriptive geometry, and drawing, and the general principles of mechanism fundamentally necessary to the higher branches of horology, could be imparted at the same time. That all these have resulted in bettering the quality of the work produced in that country is clearly shown by a comparison of the results of the competitive or other trials of the watch movements from year to year.

Pocket chronometers of the first class are subjected to trial for six weeks, in five positions and in the oven, namely: first week, horizontal position, in the oven one day; second week, horizontal position; third and fourth weeks, hanging. Then, in the fifth week, two days pendant left, two days pendant right, and two days dial down. Finally, the sixth week, dial up. The second grade are tried four weeks, and only in two positions, horizontal and hanging, and one day in the oven. The third grade are subjected to trial for fifteen days, to find the steadiness of the daily rate and the degree of compensation for temperature. The trials are made chiefly at the observatories of Neuchâtel and Geneva, and the annual reports made by the directors of these establishments upon the results obtained show a steady approach towards greater perfection. The report of Dr. Hirsch, director of the observatory at Neuchâtel, for 1875, gives some very interesting statistics in regard to the results produced by different forms of escapements and balance-springs, as well as in regard to the progress made during several years in perfecting the several adjustments.

The mean daily variation of the rate of chronometers having different forms of escapements were found to be as follows in the years named:

Year.	Form of Escapement.				Mean Variation of the Year.
	Anchor.	Bascule.	Spring Detent.	Tourbillon.	
	s	s	s	s	s
1862	1·51	1·80	1·02	2·30	1·61
1863	1·39	1·28	1·37	0·64	1·28
1864	1·14	1·47	1·17	0·66	1·27
1865	0·89	1·01	0·70	0·42	0·88
1866	0·67	0·73	1·01	0·35	0·74
1867	0·70	0·61	0·74	0·52	0·66
1868	0·57	0·56	0·66	0·29	0·57
1869	0·61	0·58	0·60	0·55	0·60
1870	0·53	0·62	0·52	0·40	0·54
1871	0·56	0·53	0·47	0·56	0·55
1872	0·53	0·46	0·54	0·58	0·52
1873	0·62	0·63	0·56	0·72	0·62
1874	0·54	0·52	0·48	0·60	0·53
1875	0·46	0·47	0·17	0·49	0·46
Mean variation during 14 years	s 0·601	s 0·745	s 0·706	s 0·706	s 0·652
Number of chronometers	1048	462	137	57	1704

The substantial agreement of the results for the different escapements is indicated by the numbers given in this table, so that for the purposes of a watch to be carried about in the pocket of the wearer preference should be given to the lever-escapement.

The differences of the results for different forms of balance-springs were also very slight in the case of the mean derived from a large number of fully adjusted movements. The spherical hair-spring gave the least difference between the rates hanging and lying, although the actual difference was very little in its favour. The most uniform results were obtained with a flat spiral having a single terminal curve.

The progress made in the adjustments for steadiness of the daily rate, for position and for temperature, derived from the trial, each year, of a considerable number of movements is shown by the following:

Year.	Mean Variation of Daily Rate.	Difference between Hanging and Lying.	Mean Variation for 1° Centigrade.
	s	s	s
1864	1·27	8·21	0·48
1865	0·88	6·18	0·35
1866	0·74	3·56	0·36
1867	0·66	3·57	0·16
1868	0·57	2·44	0·15
1869	0·60	2·43	0·14
1870	0·54	2·37	0·14
1871	0·55	1·90	0·13
1872	0·52	1·99	0·15
1873	0·62	2·59	0·15
1874	0·53	2·27	0·15
1875	0·46	1·97	0·13

In considering the numbers which express the mean daily variation of the rate on account of a change of one degree in the temperature, the reader will bear in mind that ten degrees of the centigrade scale are equivalent to eighteen degrees Fahrenheit.

L. Frankfeld and Co., Geneva.

Their watch movements have the escapement on a small plate separate from the train, so that it may be detached and replaced with ease. They exhibited stop-watches with two independent second-hands, and also the same with two independent minute-hands for intervals in excess of one minute. There were three stop-pushes, and notwithstanding the complexity there was a large balance and escapement, about the same as would be placed in a watch of the same size with simple movement. The movements were apparently well sprung, and the action of the stop-work was found to be prompt. The movements had been adjusted for temperature and for position, but in one case only was the observatory certificate exhibited, and this showed that the final adjustments for that movement had been properly made.

J. M. Badollet, & Co., Geneva.

A collection of watches noticeable for the general good workmanship in the construction of the movements and in the decoration of the cases. Their watches have the usual adjustments, for those of their grade, for errors of temperature and position. In the collection were calendar and repeating watches, and a little watch whose diameter was only four lines.

Henry Grandjean & Co., Locle.

His marine chronometers have already been mentioned. He exhibited also pocket chronometers which were of a quality quite in accordance with that of these marine chronometers. One of them, No. 29,260, had a new mechanism for winding which appeared to be safe and effective. Another, No. 3,412, a

repeater, was constructed upon a new system, claimed to be more simple than the usual construction, beside having the great advantage of greater compactness. No. 29,708 is a calendar watch and chronograph. It has two distinct sets of hands separately adjustable, and the calendar is complete except for the intercalary day in leap year. For a complicated movement this is an excellent production, and the makers are entitled to the highest credit for skill in their profession. Beside pocket chronometers of the higher grades, there were exhibited by the same makers watches of medium price, which were in all respects well made.

The results of the trials of the fully adjusted movements, shown in this exhibit, as furnished by the Observatory of Neuchâtel, are as follows:

					Difference between						
						Hanging and					
Number.	Mean Daily Rate.	Mean Daily Variation.	Variation for 1° Centigrade.	Before and after Oven.	Lying and Hanging.	Pendant Left.	Pendant Right.	Dial Up and Down.	First and Last Weeks.	Extreme Rates.	
	s	s	s	s	s	s	s	s	s	s	
34,060	+6·26	±0·45	−0·22	+0·8	+2·46	−3·96	−0·06	−2·51	+3·07	9·0	

This watch has bascule escapement and flat spiral balance-spring, with double Phillips's terminal curves.

Bréting frères, Locle.

This firm exhibited two pocket chronometers having anchor escapements and flat spiral balance springs with double terminal curves, Phillips's form. The finish of the parts was good, and the character of the adjustments is shown by the following results of the trial by Dr. Hirsch:

					Difference between						
						Hanging and					
Number.	Mean Daily Rate.	Mean Daily Variation.	Variation for 1° Centigrade.	Before and after Oven.	Lying and Hanging.	Pendant Left.	Pendant Right.	Dial Up and Down.	First and Last Weeks.	Extreme Rates.	
	s	s	s	s	s	s	s	s	s	s	
47,811	−2·12	±0·29	+0·01	+0·5	+1·14	−0·68	+1·02	−0·76	+0·72	3·2	
47,812	−2·28	0·31	−0·17	+0·4	−1·01	+2·24	+0·74	+0·12	−0·37	3·4	

H. R. Ekegren, Geneva.

This maker is well known for the excellent performance of his adjusted watches. One of his movements was taken down and all its parts minutely examined. Throughout were evidences of the exact workmanship so necessary to the perfect action of the train and the escapement, and the accuracy of the adjustments is shown by the results of the trials at the observatory at Geneva, by Professor Plantamour, before the watches were sent to Philadelphia. The results of the trials were as follows:

Number.	Mean Daily Variation.	Mean Error of Position.	Mean Variation for 1° Centigrade.
	s	s	s
16,522	±0·49	±1·10	±0·02
16,518	0·89	2·24	0·29
16,519	0·34	1·42	0·24
16,588	0·76	1·42	0·11
16,779	0·48	0·90	0·16
(Second trial).	0·30	1·47	0·18
16,766	0·53	2·02	0·09
16,710	0·49	1·62	0·14
16,726	0·37	0·93	0·32
16,753	0·41	2·61	0·28
16,691	0·80	0·79	0·03
16,642	0·51	1·32	0·27
16,903	0·65	1·38	0·01

H. L. Matile, Locle.

Pocket chronometers with simple or complicated movements. No. 10,697 is a double chronograph, with calendar and moon's phases and minute repeater. The complicated mechanism is well finished and compactly arranged. No. 10,661 is also a minute chronograph. It has a simple mechanism to secure the operation of the movable minute hand.

The trials of the movements on exhibition at the Observatory of Neuchâtel gave the following results :

Number.	Mean Daily Rate.	Mean Daily Variation.	Variation for 1° Centigrade.	Before and after Oven.	Difference between Lying and Hanging.	Hanging and Pendant Left.	Hanging and Pendant Right.	Dial Up and Down.	First and Last Weeks.	Extreme Rates.
	s	s	s	s	s	s	s	s	s	s
10,045	+2·58	±0·51	−0·01	−1·6	+2·64	+1·82	+0·62	−1·19	+1·09	5·7
10,661	+4·09	0·86	−0·18	+0·1	+4·87	Chronometer of second class.				11·6
10,697	−3·84	0·70	−0·31	−0·5	−0·52		„	„		7·9
10,571	−2·55	1·18	+0·18	+0·5	+1·48		„	„		7·8

In connexion with this exhibit were shown also some specimens of the work of Mr. Charles Meylan, inventor of a new form of minute chronograph. One was a minute chronograph, and also a minute repeater, both in one combination, of compact and elegant construction. Mr. Meylan is a resident of New York, but the complicated watches upon his plan are constructed by Mr. Matile, in Switzerland.

Patek, Philippe, & Co., Geneva.

Watches of various grades. The makers employ a variety of labour-saving machines in their construction. To a limited extent they construct parts which are interchangeable for the same grades of movements. Besides the watches of ordinary grades, this house has long had an excellent reputation for skill in the manufacture of fully adjusted movements, and for the artistic decoration of the cases of their watches.

The fully-adjusted watches which they exhibited had been subjected to trial at the Observatory of Geneva, and the following are the results shown by the certificates furnished by Professor Plantamour :

Number.	Mean Daily Variation.	Mean Error of Position.	Mean Variation for 1° Centigrade.
	s	s	s
42,948	±0·45	±1·23	±0·03
46,201	0·49	1·63	0·21
49,264	0·66	1·79	0·10
49,265	0·64	1·21	0·09
42,962	0·42	1·48	0·11
44,035	0·54	2·66	0·13
47,776	0·39	2·09	0·11
47,417	0·49	1·60	0·07
41,659	0·72	+2·20	−0·01
34,038	0·58	+1·55	+0·12
		Difference between Hanging and Lying.	
49,027	±0·38	+5·89	−0·33
49,111	0·61	−2·40	+0·64
49,062	0·55	+1·82	+0·26

Tiffany & Co., New York, N. Y.

A collection of movements quite similar to these, constructed at a factory formerly belonging to them in Geneva, but now merged into that of Messrs. Patek, Philippe, & Co.

Messrs. Jacot Frères, Locle.

Exhibited a collection of complicated watches. The minute repeaters had a novel arrangement of the striking parts, and there was also a pointer on the dial to show the winding, the mechanism for which is ingenious, simple, and

efficacious. The watches had been tried at the Observatory of Neuchâtel, and the following were the results obtained :

Number.	Mean Daily Rate.	Mean Daily Variation.	Variation for 1° Centigrade.	Before and after Oven.	Difference between Lying and Hanging.	Difference between Extreme Rates.
	s	s	s	s	s	s
199,313	−1·40	±0·33	+0·01	−0·8	+2·74	4·6
199,315	−4·78	0·42	+0·44	+1·5	−3·59	14·7
199,311	−2·47	0·45	−0·05	+1·9	+3·34	6·6
199,307	+1·03	0·45	+0·28	+1·2	−0·94	8·4
199,309	+0·88	0·53	+0·37	+0·4	−0·88	9·9
199,310	−4·12	0·67	+0·19	+4·5	−3·40	10·6
199,308	−2·37	0·80	+0·19	+0·2	−0·17	6·1
199,314	+1·35	0·80	+0·21	−0·9	+2·52	9·2
199,312	+5·43	1·38	−0·07	0·0	+4·96	10·7

These watches had anchor escapements and flat-spiral balance-springs, with single Phillips's terminal curves. With a single exception, they were complicated movements.

Louis Audemars, Brassus.

This maker is reputed to be one of the most accomplished manufacturers of watches in Switzerland. His exhibit consisted of a collection of simple and complicated watches. Some of the pocket chronometers had fusees and cylindrical balance-springs, and the whole workmanship was apparently of the highest order. These watches were reported to be fully adjusted, but they had not yet been subjected to any timing test at an observatory, and they were not submitted for trial at Philadelphia. One of the repeaters was a clock-striking, minute repeater, striking the hours and quarters like a clock, and repeating the hours, quarters, and minutes at will. Another minute repeater had also perpetual calendar and phases of the moon, the complicated construction of which was exceedingly compact. There was also a little ten-line minute repeater, with stem-winding, flat-spiral balance-spring, with Phillips's terminal curves, adjusted for temperature and position.

A. Hugenin & Sons, Locle.

A collection of simple and complicated watches, and escapements for fine clocks. One of the watches had a tourbillon escapement. Their movements are constructed upon an excellent model, and, so far as could be seen, the workmanship was in all respects good. Two of the chronometers had been tried at the Observatory of Neuchâtel. One of them was a perpetual-calendar watch, with phases of the moon, anchor escapement, and double Phillips's terminal curves. Its performance under trial is shown by the following :

Number.	Mean Daily Rate.	Mean Daily Variation.	Variation for 1° Centigrade.	Before and after Oven.	Difference between Lying and Hanging.	Difference between Hanging and Pendant Left.	Difference between Hanging and Pendant Right.	Dial Up and Down.	First and Last Weeks.	Extreme Rates.
	s	s	s	s	s	s	s	s	s	s
15,633	−1·79	±0·82	−0·29	0·0	−2·80	−4·01	+2·34	−4·49	−3·45	9·4
15,001	+5·69	0·57		Pocket chronometer of the third class						3·6

The second of these is a double chronograph, with independent seconds and quarter-second hand.

Borel & Courvoisier, Neuchâtel.

Pocket chronometers, and watch movements made of uniform size for each grade. The complicated movements exhibited by them had the ordinary arrangement of the mechanism, but they were exceedingly well constructed. One of their pocket chronometers, No. 54,025, shown at the Exhibition, had

received a prize at the competitive trial at Neuchâtel in 1875, and the following are the results of the trials of this and others shown in their exhibit:

Number.	Mean Daily Rate.	Mean Daily Variation.	Variation for 1° Centrigrade.	Before and after Oven.	Difference between Lying and Hanging.	Hanging and Pendant Left.	Hanging and Pendant Right.	Dial Up and Down.	First and Last Weeks.	Extreme Rates.
	s	s	s	s	s	s	s	s	s	s
54,045	+2·49	±0·69	−0·21	−0·7	−4·44	−2·67	+0·03	−2·41	−3·69	9·8
54,059	+1·59	0·20	−0·02	+0·7	+0·19	+1·82	+2·47	+0·15	+2·22	4·0
54,023	+0·86	0·26	−0·03	+4·3	+0·95	+2·50	+2·60	−0·37	+4·52	6·3
60,008	+0·27	0·21	−0·14	−0·3	+0·23	Not observed.		Class II.		6·0
54,025	+2·21	0·16	+0·08	+0·8	+1·16	„		„		2·9

These chronometers have anchor escapements and flat spiral balance springs, with single Phillips's terminal curves.

Charles Martin & Co., Geneva.

A collection of watches of their manufacture worthy of mention, on account of the quality of the workmanship shown in the movements, and on account also of the artistic decoration of the cases.

James Nardin, Locle.

Mr. Nardin is reputed one of the best manufacturers of watches in Switzerland. He exhibited a collection of pocket chronometers of his own manufacture made specially for the International Exhibition. They had not been subjected to trial at an observatory, and were not submitted for trial at Philadelphia. Among them were repeaters, chronographs, and calendar watches. Besides the adjusted watches, there were movements of ordinary commercial grades.

Carl Taglieb, Zurich.

A watch in a large finger ring, which was ingeniously arranged. Turning the watch movement in one direction in the ring winds up the springs, and in the other direction it sets the hands. There is a detent which clamps it when the hands are set.

Désiré Colliot, St. Imier.

Cheap watches in silver or silver plated cases, also a complete movement of four line size, and a watch in a ring also about four line size. It winds as a stem winder. The hands are adjusted from a little door in the side.

R. S. Rigtrup, Locle.

A new mechanism for watches without fusee. It is an ingenious and efficacious arrangement by which, in a watch without a fusee, a hand on the dial shows whether it is wound up or not, as well as the number of hours elapsed since the winding.

Daniel Ducommun, Gorgier.

A collection of watch movements for which the particular merit claimed is the neatness and strength of the model. The form is similar to that of the Jurgensen watches.

Ernest Francillon & Co., St. Imier.

Watches in the manufacture of which labour saving machines are used, and for which many of the parts are interchangeable. The movements exhibited were all of cheap grades.

J. B. Bitterlin-Schmidt, Locle.

Specimens of finished jewels for watches and precious stones for watch cases which showed excellent workmanship.

EUGÉNE BESANCET-BLANC, Travers.

A collection of finished watch jewels and specimens of setting of jewels. In this exhibit was shown a ruby pinion, and also a ruby cylinder for a cylinder escapement, and ruby rollers for chronometer escapements. The workmanship exhibited in this collection was of the highest order, and worthy of special commendation.

Watches of ordinary commerical grades were exhibited by G. HONEGGER, of Bienne; GABRIEL DIDISHEIM, of St. Imier; AEBI & LANDRY, of Madretsch; ALLIANCE HORLOGÈRE, of Chaux-de-Fonds; FAVRE FRÈRES, of Neuveville; D. PERRET FILS, of Neuchâtel; A. & E. CHATELAIN & WOELFLIN, of Geneva; MAURICE STAHL, of Chaux-de-Fonds; and ERNEST HUMBERT, of Locle.

AMI RAUSS, Geneva.

Fifty specimens of dial work, some of which required microscopic aid in the examination.

J. CORCELLE & Co., Geneva.

A large collection of dials, constructed for manufacturers of watches for various countries, the painting of which was in excellent taste and microscopically exact.

DUFAUX, LUTZ, & FILS, Geneva.

A collection of balance springs, cylindrical, globular, and flat spiral, in both blue and white, of ordinary quality.

BAEHNI FRÈRES, Bienne.

A large collection of balance springs, and also wire for springs, to be commended for the excellent quality and variety of that manufacture.

C. MONTANDON GENTIL-LUTZ, Servette.

Flat spiral and cylindrical balance springs, for watches, which bore admirably tests for evenness of gauge, elasticity, hardness, &c.

AIMÉ PERRENOUD, Geneva.

A collection of steel and gold balance springs, in form flat, globular, or cylindrical, the qualities of which are great elasticity and toughness, evenness of gauge, and correctness of winding.

Main-springs for watches, of good quality, were exhibited by E. KLEIN, of Geneva; CHARLES JEANJAQUET, of Neuchâtel; EDWARD BERLIE, of Geneva; and AUBERT FRÈRES, of Savagnier. Those by the latter are to be noticed particularly for their good quality in connexion with the very moderate prices charged.

F. P. INGOLD, Chax-de-Fonds.

Fraises or cutters for finishing the teeth of wheels.

J. E. ANTONY-BOVY, Chaux-de-Fonds.

Watch hands, stems, rings, detached parts for stem winders, and steel wheels.

To mention fully the instances of ingenious contrivance and skilful execution of the mechanism shown in a collective exhibit of the productions of Swiss watchmakers is impossible in a brief report. The attention of the people of a considerable portion of Switzerland having been, for nearly two centuries, directed in this particular channel, all sorts of devices have been invented and re-invented. Whatever has been found to be of practical utility has been put

into use, and what has proved to be impracticable has been laid aside. Not the least remarkable is the skill which they have shown in the production of watches which are really instruments of precision, In this they cannot, however, expect a monopoly; and whatever may be the result as to the crisis which now seriously disturbs their business, they can certainly expect to hold the undisputed control of the manufacture of all kinds of complicated watches. In this field of production they are without rivals.

REPORT

OF THE

DIRECTOR OF THE BUREAU OF MEDICAL SERVICE.

REPORT OF THE DIRECTOR OF THE BUREAU OF MEDICAL SERVICE.

The functions of the Medical Department were to supply medical and surgical assistance within the Exhibition grounds; to advise with reference to sanitary questions; and to issue in authoritative form such information on the sanitary condition of Philadelphia and of the Exhibition as might be desirable. The important subjects of the drainage and water supply of the Exhibition grounds were placed entirely under the control of the Chief Engineer of the grounds.

The Medical Department was organised in the early part of 1876, by the appointment of a Medical Director, a staff composed of six Medical Officers, and a Secretary, who was also the Resident Physician at the Hospital in the Exhibition grounds.

MEDICAL DEPARTMENT.

Medical Director:

WILLIAM PEPPER, M.D.

Officers of Medical Staff:

JACOB ROBERTS, M.D.	ROLAND G. CURTIN, M.D.
S. W. GROSS, M.D.	HAMILTON OSGOOD, M.D.
H. C. WOOD, JR., M.D.	DE FOREST WILLARD, M.D.

Resident Physician and Secretary:

THEODORE HERBERT, M.D.

[There were also employed a nurse, two apothecaries, and four attendants and clerical assistants.]

The Hospital was centrally located in Landsdowne Ravine, on Landsdowne Avenue, between Agricultural and Belmont Avenues. Its position was retired, well shaded, and quite picturesque. The building was a one-storied frame structure, 64 feet by 32 feet, well lighted and ventilated, and conveniently arranged, having a large waiting-room, No. 1, 19 feet 6 inches by 19 feet 6 inches; the office of the Medical Staff and of the Apothecary, No. 2, 19 feet 6 inches by 12 feet 6 inches; the office of the Director and Secretary, No. 3; the private room of the Resident Physician, No. 4; two wards, Nos. 5 and 6, for male and female patients, each 16 feet by 20 feet; two bath-rooms, and a private room for the nurse. It was furnished with every necessary convenience and comfort, and in every way answered the purposes for which it was intended.

The Hospital was first occupied on the opening day of the Exhibition, May 10, and from that time until November 15, when the Exhibition was finally closed to the public, the above organization was maintained in efficient operation.

The experience of previous International Exhibitions has been that exaggerated statements are circulated as to the bad sanitary condition of the cities in which they have been held; and a circular was accordingly issued, April 15, 1876, in which the sanitary condition of Philadelphia was fairly represented. This circular was widely distributed, and was extensively reprinted at home and abroad.

Prior to the opening of the Exhibition the duties of the Medical Department were chiefly limited to the care of the employés engaged in the construction of the various buildings or in the preparation of the grounds, and of the attachés of the Foreign Commissions, who early began to take up their residence within the grounds. It is a gratifying fact that although many thousands of workmen were engaged for eighteen months in the construction of the buildings, the number of casualties was very small. In order to provide fully for these, Dr. Herbert was at an early day stationed in a convenient office on the grounds, so that all such cases might receive immediate attention. As there was telegraphic communication with the nearest general hospital, that connected with the University of Pennsylvania, there was no delay in having any serious case transferred in an ambulance to its wards.

With the opening of the Exhibition began the active work of the Medical Department, but for the first few weeks the public evidently were not fully aware of its existence. It is probable that from this cause many cases of sickness, occurring during this time, did not come to the Hospital for relief. This was remedied by an announcement, which was posted throughout the Exhibition Buildings and grounds.

Owing to the great number and size of the buildings, and the distances between them, it was necessary to place stretchers at numerous points in each of the principal buildings and about the grounds. The guards were especially instructed to promptly convey to the hospital any person requiring medical relief. In addition to this an ambulance was kept standing in constant readiness to be dispatched to any part of the grounds for cases of a more serious character. The ambulance was also used in exceptional cases for conveying patients to their residences in the city, or to one of the neighbouring hospitals, after the hours of the Exhibition.

For the efficient and satisfactory working of the Hospital Department the following rules were issued:

1. The Hospital building does not contain any exhibit; it is intended solely for medical purposes, and, as its wards are always occupied, visitors will not be admitted. Information concerning the Department can be obtained from the Resident Medical Officer.
2. All medical relief furnished at the Hospital building being gratuitous, under no circumstances will any remuneration be received for services rendered. No medicines will be sold, nor will any be dispensed excepting upon the prescription of the officers of the Department.
3. In order to avoid undue publicity of personal details, the record of the daily work of the Hospital furnished to the agents of the public press will embrace only the number and general character of the cases treated.
4. No patient will be permitted to remain in the Hospital building over night. All patients remaining in its wards at the hour of closing the Exhibition will be transported to their residence by the ambulance or by private conveyance.
5. All employés of the Board of Finance, of the Centennial Commission, and of Foreign Commissions requiring medical treatment, shall report daily to the Resident Medical Officer, at such an hour previous to the opening of the Exhibition as he shall designate.
6. Any case of serious sickness occurring among the employés must be reported without delay to the Resident Medical Officer, who shall immediately have the patient removed to his own residence or to one of the neighbouring civil hospitals.

In proceeding to the consideration of the medical statistics of the Exhibition, it will be convenient to allude first to the sickness occurring among the population resident within the grounds. In this connection it is important to determine what was the average extent of this population during the period of the Exhibition, though it is impossible to do this with entire accuracy, on account of the constant changes in the number of persons domiciled at the several State headquarters. It may, however, be estimated that the average daily population for the twenty-seven weeks was 1,568. The highest daily average was 1,817, during the week ending May 27; and the lowest daily average was 1,382, during the week ending November 10.

The population was distributed as follows:

Residing at the several restaurants, daily average	256
Residing at the buildings of the several foreign Commissions, daily average	103
Residing at the several State buildings, daily average	88
In the employ of the United States Government, daily average	91
" " " Board of Finance:	
Centennial Guard, daily average	802
Firemen, daily average	175
Janitors and others, daily average	53
Total	1,568

Before considering the amount of sickness occurring among this population, attention is due to the peculiar conditions involved. In the first place, among the numerous representatives of foreign countries quartered within the grounds, most of whom were sufficiently well housed and provided for, there were not a few who suffered severely from the exceptional weather of 1876—the keen cold of the early months of the year, as well as the intense heat of the summer. Unfortunately, too, some of those whose native climate would render them most susceptible to these extremes were not suitably provided for, in either lodging or food. This was particularly the case with the Japanese, who numbered about fifty; and whose dwelling, although a beautiful model of Oriental taste and workmanship, was barely suitable as a residence during the cool weather of an ordinary Philadelphia spring or fall. It was a frame structure of the lightest description, with no provision for heating excepting a small shallow box, filled with sand, placed in the centre of each room, upon which were kept burning a few small pieces of charcoal. It may be imagined, therefore, how ill-fitted this was as a residence, not only during the severe winter months, but even during April, May, September, and October. It is to be noted, in connection with this mode of heating the apartments of the Japanese dwelling, that, as there was no outlet for the fumes of the burning charcoal, nor indeed any aperture whatever for ventilation when the rooms were closed, as they constantly were during cool weather, the inmates were subjected to a most unwholesome atmosphere. These depressing influences, in connection with their meagre diet, caused considerable sickness among the Japanese. The chief forms of indisposition were diarrhœal affections, attended with an unusual degree of general prostration, which yielded readily to treatment, but were apt to recur. In addition to this, the want of acclimation and the depressing influences just mentioned, strongly predisposed them to contract febrile affections of typhoid type. Thus, out of about 50 individuals, including the members of the Japanese Commission and the Japanese exhibitors, there were 9 cases of typhoid and typho-malarial fever. These cases were all treated at the University Hospital, and all recovered. They were of a rather mild type, with a peculiar absence of diarrhœa and of symptoms of nervous disturbance. Although the cases were not severe, it was further noted that the convalescence was unusually slow and protracted.

Among the English residents, of whom there were 36,—next in number to the Japanese,—there was a moderate amount of diarrhœa, but only two cases of typhoid fever, both of which recovered. In marked contrast to the unhealthfulness of the Japanese colony is to be placed the excellent sanitary conditions of the cottages for the employees of the British Commission.

The most important question in connection with this part of our subject concerns the health of the Centennial Guard. This body, which originally consisted of 1,176 men, was selected with great care as to their physical fitness. It comprised representatives of twenty-five States; the largest number from any one being 608 from Pennsylvania, of whom only 197 were from Philadelphia, so that over 80 per cent. of all were from country districts. This fact has an important bearing upon the liability to continued febrile affections conspicuously displayed by the members of this force. In regard to occupation, about 50 per cent. of all had been engaged, prior to their enrolment, in in-door pursuits (as clerks, store keepers, printers, shoemakers, &c.), which gave the worst possible preparation for the very exposing and trying duties assigned to them as members of the Guard. Indeed, of the 50 per cent. who had previously

been engaged in what we have classed as out-door pursuits, as distinguished from those which were purely sedentary and in-door, there were several large groups (such as sailors, machinists, blacksmiths, &c.) who were not especially well-fitted to bear protracted exposure to intense summer-heat. An examination of the ages of the men enrolled, shows that every year from 21 to 53 inclusive was represented. The following table shows the relative number enrolled for each period of five years from 21 onwards:

From 21 to 25 years inclusive	223 men.
„ 26 to 30 „ „	340 „
„ 31 to 35 „ „	288 „
„ 36 to 40 „ „	211 „
„ 41 to 45 „ „	95 „
„ 46 to 50 „ „	12 „
Over 50 years of age	7 „
Total	1,176

Although the number of men actually enrolled in the Guard was 1,176, the daily average during the entire period of the Exhibition was only 802. The reduction in numbers was a gradual one, and, so far as is known, does not impair the general accuracy of the proportions we have given. Attention has been called to the above details about the composition of the Guard, because it is evident that they exerted a large influence upon the high rate of sickness which afterwards prevailed among them.

Owing to the unusual heat of the season, the uniform which was adopted proved to be much too heavy and oppressive. It must also be observed that, in the construction of the barracks in which the Guard were quartered, sufficient attention was not paid to securing free ventilation or sufficient cubic feet of breathing space. It is probable that both the health and comfort of the Guard would have been better served by requiring the men to be within the grounds only while on duty, and allowing them to quarter themselves outside.

It was inevitable, in consideration of the composition of the Guard, their arduous duty, and the extreme heat to which they were exposed, that a considerable amount of sickness should have occurred among them. This showed itself chiefly in the forms of diarrhœal and febrile affections and of solar exhaustion. The diarrhœa was of a simple character and amenable to treatment, so that it rarely necessitated the patient's being off duty. The forms of fever which presented themselves were simple intermittent, typho-malarial, and typhoid. Nearly all cases of intermittent fever occurred among those who had suffered previously with the same affection within eighteen months. In no instance did it appear that the disease was contracted for the first time upon the Exhibition grounds. It is a well-known fact that, in those who have once suffered from malaria, any cause of nervous exhaustion, such as exposure to extremes of temperature, or excessive exertion, may reproduce the symptoms of fever without there having been any fresh exposure to malarial miasm. When it is further noted that nine-tenths of the cases of intermittent fever among the Guard and other residents within the grounds occurred during the months June, July, and August, it is clear that there cannot be said to have been any marked degree of malaria about this locality. During these three months, which were characterised by extreme and dry heat, the climatic conditions were very unfavourable to the development of the malarial poison; while during the later months of the Exhibition, including the period when malaria is usually most prevalent, it was found that not more than three or four mild cases occurred.

Of the other forms of fever mentioned, typho-malarial and typhoid, it is important to speak more at length, since the attention not only of the medical profession but of the public was prominently directed to this subject. As, however, its chief interest concerned the health of the public at large more than that of the Guard, its consideration will be found in a later part of this report. (See pages 872–874.)

It is difficult to determine accurately the number of cases of typhoid fever occurring among the Guard. This is chiefly because, on the development of any symptoms of a suspicious character, the patients were in most instances removed to their homes, and all future record of the cases was lost. It is

certain, however, from the observation of cases of this character sent to Philadephia hospitals, that many of them proved to be simple diarrhœa, with unusual prostration. On the whole, it may be said that not more than from 25 to 30 cases of true typhoid or typho-malarial fever occurred among the Guard, whose average number during the months of May, June, July, and August, during which time all of the cases of fever originated, was 870. When we recall the conditions upon which we have dwelt as rendering the members of the Centennial Guard unusually liable to these febrile affections, it becomes evident that the specific causes of typhoid and typho-malarial fevers did not exist in any high degree of intensity at the Exhibition grounds.

The total number of deaths known to have occurred among the Guard is 8, from the following causes:

Typhoid and typho-malarial fevers, after removal to their homes in other States	3
Typhoid and typho-malarial fevers, after removal to hospital	3
Organic disease of the heart, with rupture, after removal to hospital	1
Variola, after removal to hospital	1

In connection with this latter case it is interesting to observe that it was developed in one of the Guard who was quartered in a crowded barrack, and that it was the only case of small-pox that occurred. In like manner, a single isolated case of severe measles presented itself in a different barrack.

In further confirmation of the view that the causes of the typhoid fever which occurred were general in their character, and connected with peculiar atmospheric conditions and with the peculiar composition of the population resident within the grounds, there should be mentioned, first, that the cases all occurred during the months of May, June, July, and August; and, secondly, that they were quite evenly distributed over the extensive grounds; thus there were cases among the Guard at the barracks on George's Hill, among the Japanese and English at their quarters on the Hill, among the Guard at the Fifty-second Street barracks, among those at the barracks at the eastern end of the Main Building, among those at the barracks at the north-eastern extremity of the grounds, and among those at the barracks immediately in front of the Hospital, which was almost in the centre of the inclosure. It seems remarkable that at the barracks of Company G, which was situated in Belmont Ravine, between the Kansas and Colorado Building and Agricultural Hall, there was not a single case, as this location seemed to present the least favourable hygienic conditions of all.

Apart from the diarrhœa and fevers which have been spoken of, the general health of the Guard was good, the only ailments being of a very trivial character.

It may be stated, in conclusion, that, considering the great exposure of the Guard, of the employés, and of the attachés of Foreign Commissions during the cold inclement weather of March and April, and later during the unprecedented heat of June, July, and August, their health was better than could have been anticipated.

As yet there have been considered only those sanitary questions connected with the population resident within the grounds. It now remains to examine the interesting questions which concern the extraordinary number of visitors who thronged the Exhibition during the twenty-seven weeks of its continuance.

As already stated, during the first few weeks it was not generally known to visitors that provision for medical relief had been made. In view of the frequent calls subsequently made upon the Department, and the valuable assistance rendered in many cases, it seems desirable that hereafter in similar Exhibitions the Medical Bureau should be organised at a very early date, and that the attention of the public should be called to it in the clearest possible manner.

On the opening day, May 10, although there were 186,672 visitors, there would seem to have been no serious accidents, since but 5 cases applied at the Medical Department, 3 of which were slight injuries and 2 were cases of exhaustion. It is probable, however, that there were many other similar cases which were removed directly to their homes, and of which consequently no record has been kept. From that date to the closing day (159 days in all), 6,463 cases were treated, making a daily average of about 41.

The following analysis of the actual residences of the cases, although of course not in any way proving that the same proportions held in regard to the entire number of visitors, is of interest:

I.—Residences of Patients.

Austria	2	Alabama	14	Nevada	2
Bavaria	1	Arkansas	7	North Carolina	14
Belgium	4	California	32	New Hampshire	66
Bohemia	1	Colorado	8	New Jersey	249
Brazil	3	Connecticut	292	New York	1,268
Canada	68	District of Columbia	65	Ohio	318
Cuba	1	Delaware	42	Oregon	1
England	55	Florida	9	Pennsylvania	2,104
France	23	Georgia	18	Rhode Island	58
Germany	21	Illinois	116	South Carolina	11
Ireland	11	Indiana	97	Tennessee	15
Italy	4	Iowa	64	Texas	11
Japan	32	Kansas	21	Vermont	79
Jerusalem	1	Kentucky	20	Virginia	58
Norway	1	Louisiana	6	Wisconsin	48
Nova Scotia	11	Massachusetts	495	Not known	165
Poland	1	Maryland	139	Total	6,463
Portugal	1	Maine	42		
Prussia	4	Michigan	163	United States	6,016
Russia	13	Minnesota	7	Foreign countries	282
Syria	2	Mississippi	16	Not known	165
Scotland	2	Missouri	33		
Sweden	12	Montana	1	Total	6,463
Turkey	7	Nebraska	7		
West Indies	1				

It is seen from the above table that 93 per cent. of all persons treated were residents of the United States, representing 39 States and Territories; while but 4·36 per cent. of all were from foreign countries. Of those from the United States, 35 per cent. were from Pennsylvania, 21 per cent. from New York, 7·6 per cent. from Massachusetts, 4·9 per cent. from Ohio, 4·5 per cent. from Connecticut, and 3·8 per cent. from New Jersey. Of those from foreign countries, 55 were from England, 32 from Japan, 23 from France, and 21 from Germany.

Of the total number of cases (6,463), 1,799 were females and 4,664 were males.

II.—Ages of Patients.

Ages.	Males.	Females.
Under 1 year	5	1
1 to 5 years	17	9
5 to 10 „	51	26
10 to 20 „	449	222
20 to 40 „	2,348	759
40 to 60 „	885	285
60 to 80 „	145	38
80 to 100 „	1	2
Not given	763	457
Total	4,664	1,799

The oldest patients included in the above table were one man aged 81, and two women aged respectively 95 and 96 years; while, on the other hand, the youngest patients were 2 and 4 weeks respectively.

The following tables present a summary of the principal causes of sickness among the visitors to the Exhibition during the twenty-seven weeks of its continuance:

III.—Medical Cases.

Respiratory and Circulatory Diseases.	
Asthma	9
Hay asthma	2
Bronchitis	135
Hæmoptysis	13
Organic disease of heart	8
Palpitation of heart	13
Miscellaneous	66
Total	246
Digestive Diseases.	
Cholera infantum	1
Cholera morbus	151
Diarrhœa	1,686
Dysentery	19
Indigestion	499
Cramps	487
Constipation	215
Miscellaneous	141
Total	3,199
Nervous Diseases.	
Apoplexy	2
Headache	356
Neuralgia (including tooth-ache and ear-ache)	364
Epilepsy	28
Hysteria	50
Insanity	2
Vertigo	55
Menière's disease	1
Miscellaneous	7
Total	865
Fevers.	
Simple fever	27
Intermittent fever	212
Remittent	5
Typhoid	6
Total	250
Effects of Heat.	
Heat exhaustion	29
Thermal fever	10
Sun-stroke	2
Total	41
Effects of Over-exertion.	
Debility and exhaustion	266
Faintness and syncope	44
Total	310
Intemperance	10
Miscellaneous medical cases	596
Total medical cases	5,519

IV.—Surgical Cases.

Wounds.	
Bites and stings	25
Contused wounds	56
Incised wounds	73
Lacerated wounds	100
Gunshot wounds	3
Punctured wounds	11
Total	268
Accidents and Injuries.	
Scalds	14
Burns	12
Contusions	96
Dislocations	4
Sprains	64
Fractures	12
Fractured larynx	1
Concussions	4
Foreign body in eye	192
Foreign body in ear	1
Foreign body in throat	4
Hernia	4
Hernia (strangulated)	6
Total	414
Miscellaneous surgical cases	262
Total surgical cases	944
Medical cases	5,519
Surgical cases	944
Total	6,463

About one-fourth of these cases were of such severity as to require admission to the Hospital wards, while the remainder were capable of being immediately relieved. In the vast majority of cases the patients admitted to the wards recovered so speedily as to be able to return home without aid. In not more than 35 instances during the entire season did the patients continue so ill as

to make it necessary to have them conveyed to their homes in the ambulance when the Hospital was closed at nightfall. In no instance was it necessary to deviate from the rule of the Department, that no case of sickness should remain in the Hospital building over night.

It will be observed that 3,199, or more than one-half the entire number of medical cases, were connected with the digestive organs. Although the majority of these originated at the Exhibition, a considerable number were cases of longer standing. It is important to note this, not only in connection with this class of affections, but with all the other classes, since, in reality, a considerable proportion of the cases were in no way chargeable to the visit to the Exhibition. Thus, so soon as it became generally known that gratuitous medical advice could be had, a large number of persons with chronic affections of a medical or surgical character applied at the Department for relief. It was thought expedient not to refuse such applications, although they were recognised as an abuse of the Medical Department, which was intended solely for the relief of cases of emergency. The great majority of the cases of digestive disturbance were directly traceable to excesses or indiscretions in eating; and, when it is remembered that such vast numbers of persons, collected from all classes of society and accustomed to all varieties of occupation and climate, were exposed to the combined influence of excessive fatigue and excitement, of extreme heat and of irregular diet and hours of eating, it is truly remarkable that sickness from these causes was not vastly more common. It should also be observed that in supplying the enormous demand for certain articles of food it must occasionally have happened that supplies of inferior quality were used. This was particularly the case with regard to articles of such perishable character and of such general consumption as milk, meat, eggs, &c. A forcible illustration of this was given on the 11th of July, when no less than 26 patients with severe cholera morbus were admitted to the hospital in the course of an hour and a half, all of whom had been taken ill soon after partaking of a lunch of pie and milk at one of the restaurants. It cannot be doubted that this violent outbreak was dependent upon some subtle organic change in one of the articles mentioned, probably the milk, by which it acquired highly irritant poisonous qualities. Probably, however, sickness was less frequently caused by such spoiled or tainted provisions than by excessive fatigue in very hot weather, by the copious use of iced drinks of all kinds while the body was greatly overheated, and by the consumption of indigestible articles of food when in a state of great physical exhaustion. Vast numbers of those who visited the Exhibition did so at great personal and pecuniary sacrifice. Every effort was made, therefore, to condense their visit to all parts of the Exhibition into the shortest possible time, and it is difficult to conceive of the excessive fatigue and exhaustion involved in this attempt. A large proportion of the visitors were women or young persons entirely unfitted for enduring the physical fatigue of a succession of long days, spent on foot, in constant motion, in the midst of vast throngs of people, and with the mind overtaxed with the ever-changing novelties and attractions of the scene. Very many of the visitors came from localities whose climates differed widely from that which they here found. They abruptly changed all their habits of living, and, in too many instances, neglected the hygienic rules which are essential to health.

During the later months of the Exhibition, there were unfavourable reports circulated in regard to the purity of the drinking-water supplied to the Exhibition grounds and the neighbouring portion of West Philadelphia; but careful investigation showed that they were unfounded. The water was drawn from the Schuylkill River at a point opposite the Exhibition grounds. It is true that, in the extreme haste with which many of the small buildings within the inclosure were erected, the rules issued on this subject were disobeyed in a few instances, and wells were constructed having connection with one or the other of the two small streams which flowed through the grounds and emptied into the river not far from the above point. In every case, however, this was soon detected and instantly corrected. Any contamination of the water-supply from such a source could only have occurred during the first few days of the Exhibition. As a matter of fact, no sickness occurred during this period. Careful analyses were made at short intervals by Dr. C. M. Cresson, which showed that the purity of the water taken from this point of the Schuylkill was fully up to the standard of previous years as well as to that of the water-

supply of neighbouring cities. The most conclusive evidence, however, on this point is to be drawn from the actual experience of the large number of persons who drank the water freely during the entire period of the Exhibition, but who were not exposed to the various causes of sickness which influenced the Guard and visitors. In no single instance did any sickness of a typhoid or diarrhœal character occur. We have already seen that the amount of typhoid fever among the Guard was small, taking into consideration the peculiar composition of that body, and, further, that the cases which occurred took place within a limited period, marked by unusual meteorological conditions, while the water-supply remained unchanged. Finally, we have seen that the cases of diarrhœa occurring among the Guard were light in character and readily amenable to treatment, though all the time the patients were using large quantities of this drinking-water.

As a further evidence of the fact that no special cause of typhoid fever existed at the Exhibition grounds or in their vicinity, it may be stated that in the Twenty-fourth Ward, which embraces almost the whole of Fairmount Park and all of the adjoining portion of the city, the total number of deaths from typhoid fever for the entire year was 44, of which 30 occurred between May 10 and November 10. The population of this ward in 1875 was 41,310, but during the Exhibition period it may be safely estimated—in consideration of the large temporary hotels, all of which were included in this ward, and the enormous number of boarding-houses and private residences which were constructed for the occasion—that the population was at least 75,000, which gives a rate of mortality per 1,000 from typhoid fever during this period of only 4.

In conclusion, we may state, as the result of careful study of this question of the sanitary condition of the Exhibition grounds, in regard to which so much was said at the time:

First, that there is no evidence to show that any special cause of sickness existed there.

Second. That with regard to the supply of drinking-water in particular, there is no evidence to show that its use predisposed either to typhoid fever or to diarrhœal affections.

Third. That the sickness occurring among the Guard and employés resident within the grounds was due to peculiar causes above considered, which were in no way connected with the sanitary condition of the grounds.

Fourth. That the sickness occurring among the visitors, which was actually dependent upon their visit to the Exhibition, was due exclusively to the effects of over-fatigue, indiscretions in eating and drinking, undue exposure to great heat or to inclement weather, &c.

It remains now in connection with the record of sickness among the visitors to allude to a few peculiarities.

A considerable number of cases showed, as would have been expected, the injurious effects of the extreme heat. Doubtless, this cause aided in producing many of the cases classed as simple exhaustion The cases, however, in which sickness was directly traced to the effect of heat were 41 in number, of which 32 occurred between the 25th of June and the 22nd of July, during which four weeks the average temperature was 81¾° F. The majority of cases, 29 in number, presented the ordinary symptoms of nervous exhaustion following upon exposure either to the direct rays of the sun or to a very high degree of temperature within-doors. In the 10 cases recorded as thermal fever, the symptoms were much more severe. The patients were still conscious, or in some cases delirious; there was intense heat of surface, congestion of the eyes, deep flushing of the face, and great rapidity of the pulse. These cases were treated by immersion in baths of ice-water, and promptly recovered. The 2 cases recorded as sun-stroke were characterised by sudden and alarming development of temperature, the patients almost instantly passing into a state of coma with stertorous respiration, with livid congestion of the face and surface, and with extremely small and rapid pulse. They were stripped and then vigorously rubbed with pieces of ice until a marked reduction of temperature took place. As this occurred, consciousness returned, followed in both cases by rapid recovery.

In regard to the class of nervous diseases, there are several points of interest to be noted. Thus, there were but two cases of apoplexy, one of which occurred

in an intemperate man, and proved almost immediately fatal, while the other was a mild attack, probably of localised apoplectiform congestion of the brain, occurring in a young man engaged as a chair-pusher, an occupation which involved exhausting effort and prolonged exposure to the sun. There were only 28 cases of epilepsy treated at the hospital among 9,910,966 visitors to the Exhibition. It is of course highly probable that very many more epileptics were included in this number who were not so unfortunate as to have an accession of their terrible malady while within the grounds. The cases recorded as vertigo were almost exclusively dependent upon indigestion. As a matter of purely medical interest, it may be mentioned that a single case of that rare affection, Menière's disease or labyrinthine vertigo, presented itself at the Department.

The only remark to be made in connection with the class of respiratory and circulatory diseases is to call attention to the very small number of cases, only 21, who were attacked with disturbance of the heart, either due to functional or organic disease; as well as to the very small number of cases of hæmoptysis, only 13, which occurred among the enormous number of visitors. We have already remarked that the large number of cases of digestive disorders, 3,199, were nearly all attributable to excesses or indiscretions in eating or drinking, with the exception of cases of a chronic character.

In illustration of the class of persons who visited the Exhibition, it is to be observed that but 10 cases of intoxication were brought to the hospital for treatment. It was anticipated that a considerable number of cases of abortion or miscarriage would occur in consequence of the excessive exertions and fatigue incurred by many visitors to the Exhibition. In but one case, however, did abortion result; and in one other miscarriage was threatened, but was averted by rest and the use of opium.

There were but 4 deaths within the grounds during the entire period of the Exhibition. Of these, 2 occurred from organic disease of the heart and 2 from apoplexy.

The surgical cases, 944 in number, were for the most part of minor severity. It is a striking illustration of the good order which prevailed among the vast crowds which daily assembled in the grounds that there was not a single case of injury resulting from personal violence. This was especially remarkable on those days when some particular attraction drew unusually large numbers of visitors. Yet even on "Pennsylvania day," when over a quarter of a million persons were gathered within the grounds, most of whom remained until long after nightfall, so perfect was the good temper of the crowd, so entirely capable were they of taking care of themselves, and so careful to respect each other, that, although no special precautions were taken and no additional constabulary was employed, the occasion was entirely unmarked by any unusual accident. No quarrel occurred, and no woman or child was crushed or trampled upon. The passenger railway which traversed the grounds carried 68,273 persons on that day; and, although the crowded trains frequently seemed to literally plough their way through the dense masses which lined the tracks, there was not a single accident. It may be questioned whether any festival, equally remarkable in all respects, has ever occurred. It is also noteworthy, when the enormous amount of machinery in motion, and the throngs of curious visitors constantly surrounding each machine are considered, that not a single accident happened, with the exception of a few trifling contusions and lacerations occurring among the workmen. There were 3,784,142 passengers in all carried by the Narrow-Gauge Railway Company, without the occurrence of any accidents.

For the entire period of the Exhibition the ratio of cases of sickness among the visitors was 1 in every 1,533. The greatest number of patients treated in one day was 114, on September 28, "Pennsylvania Day," when there were 274,919 visitors, thus giving 1 patient in every 2,411; while on the 20th of July there were only 25,936 visitors, and 58 cases of sickness, or 1 in every 447, the highest percentage occurring during the Exhibition.

The following table shows the number of patients treated at the Hospital, and the proportion borne to the total number of visitors on the days when the attendance at the Exhibition was greatest. The mean temperature has also been placed in connection with the other data:

TABLE V.

	Number of Visitors to the Exhibition.	Number of Patients treated at the Hospital.	Ratio.	Mean Temperature, Fah.
May 10, Opening Day	186,672	5	1 in 37,334	56·7
July 4	56,494½	48	1 in 1,177	82·5
August 24, New Jersey Day	67,052	60	1 in 1,117	73·7
September 7, Connecticut Day	75,044	59	1 in 1,272	63·0
September 14, Massachusetts Day	97,868	80	1 in 1,222	68·2
September 21, New York Day	134,588	60	1 in 2,243	61·7
September 28, Pennsylvania Day	274,919	114	1 in 2,411	56·2
October 5, Rhode Island Day	100,946	48	1 in 2,103	58·5
October 12, New Hampshire Day	115,422	53	1 in 2,177	45·0
October 19, Delaware and Maryland Day	176,407	71	1 in 2,484	53·7
October 26, Ohio Day	135,661	73	1 in 1,852	45·5
October 27, Vermont Day	108,080	53	1 in 2,039	43·7
November 10, Closing Day	121,721	31	1 in 3,926	39·7

The opening day may be disregarded in this respect for the reasons already given. With reference to the other days, it will be observed that so long as the average temperature was moderate, say between 40° and 60°, the sickness among the visitors was apparently not influenced by it, but varied within certain limits from other causes. When, however, the average temperature was materially above 60°, it was found that the proportion of sickness increased considerably. As the temperature was the chief agent in influencing public health during the Exhibition, it will be interesting to subject it to a more careful study. The first feature which is apparent is the excessive temperature that prevailed during the thirteen weeks of June, July, and August. During this entire period the average weekly temperature was continuously above 70°, and during the four weeks ending July 22, the average weekly temperature was 81¼° Fah. The effects of this protracted heat were aggravated by the dry character of the season. The influence of the elevated temperature upon the amount and character of mortality in the city at large is very apparent, and will be carefully discussed later on. We would now ask attention to its influence upon the admissions to the Exhibition and upon the amount of sickness among the visitors. It will be seen that during the first 5 weeks of the Exhibition, up to June 10, there was a steady increase in the total weekly admissions to the grounds, so that for the week ending with the above date they numbered 233,406. At this time it was confidently expected that, as the travelling season was about to begin, there would be a rapid rise in the attendance. Unfortunately, however, the heated term, which was destined to be so long and so intense, began at that date. In consequence, undoubtedly, of the reports concerning the heat which were quickly circulated, the attendance, instead of increasing, immediately showed a falling off. In the week ending July 1 the number had fallen to 210,108; average weekly temperature, 81°. The total for the week ensuing, average temperature being 80°, was brought up to 315,853 by the large number of visitors attracted by the ceremonies of the 4th of July; but in the following week, with an average temperature of 83, the total fell to 174,792½; and in the week after, with an average temperature of 80°, it continued to fall, and reached the number 166,744. At this point a break in the continued heat occurred, and the attendance instantly began to rise, but it was not until the 15th week of the Exhibition that the number of visitors had attained the point where it stood in the 5th week. From this point the attendance rapidly rose, and was not longer influenced by the temperature, which continued moderate until the close of the Exhibition. While undoubtedly the total admissions to the Exhibition were seriously diminished in consequence of the extreme heat which raged during the month of July and parts of June and August, it is a matter of congratulation that large numbers of strangers did not visit Philadelphia during that time. It would have been impossible for the vast throngs which crowded the grounds during the latter part of the season to have visited them during the heated term without a lamentable amount of sickness resulting. The effects of the heat upon the general attendance at the Hospital were considerable. The fact that after the marked fall in this

attendance which followed the break in the heated term the number of cases again began to increase in the 15th week, and continued quite large during the rest of the season, was entirely due to the great and progressive increase in the general admissions to the grounds, which began at that date. Although this effect is shown in the general attendance at the Hospital, it is far more clearly displayed in regard to diarrhœal affections and the class of cases showing exhaustion in its various forms.

We invite attention, in the next place, to the sanitary statistics of the city of Philadelphia at large during the period of the Exhibition. In endeavouring to estimate the effect produced upon the health of the community by the sudden introduction of vast numbers of unacclimated strangers, it is necessary to bear in mind the peculiarities of the season and the very great differences which occur, without appreciable cause, in the mortality from some of the principal diseases in different years.

It is also highly important to determine as closely as possible the movement of the population of the city during this period. It is needless to say that, for the following reasons, this can be done with only approximative accuracy. In the first place, the floating portion of the population was directly absorbed into and blended with the resident population in a most remarkable manner. In other cities, when an occasion draws a large concourse of visitors, the additional numbers are accommodated chiefly in hotels and boarding houses. Of course a considerable number would also be received as guests into private families, but these would form but a very small proportion of the whole. On the other hand, although the hotel accommodation in Philadelphia was very largely increased in anticipation of the Exhibition, and although many additional boarding houses were opened, the great bulk of the floating population was quartered in private houses. This was partly the result of the operations of the Centennial Boarding-House Agency, which enabled all housekeepers, who so desired, to receive as many lodgers as they could accommodate; but it was chiefly due to a system of hospitality so lavish and so universal that it has probably never before been equalled. The almost unlimited extent to which this reception of guests and lodgers was carried can only be understood by recalling the fact that Philadelphia, with a population estimated in the early part of 1876 at 817,488, contained, in addition to other kinds of buildings, over 143,000 houses occupied by families, thus giving an average of less than six persons to each residence. The second source of difficulty in estimating the total population of the city lay in the frequent and extreme fluctuations which occurred in it. In the following statements, the ordinary floating population necessarily incident to the daily life of a great city is of course excluded. Bearing in mind the result of the census above given, it may be safely estimated that from May 10 to June 25, the beginning of the period of intense heat, the daily number of strangers in the city was from 30,000 to 50,000. From June 25 to August 10 the number must have fallen off considerably, and probably ranged from 15,000 to 25,000 per diem. After August 1 the number steadily and rapidly increased, so that during the last three months of the Exhibition it ranged from 50,000 to 200,000. It will be seen later that these fluctuations in the population bear an interesting relation to the variation in the amount of certain diseases. In order to serve as a basis of calculation it is necessary to decide upon a figure as representing the average population during the entire Exhibition period. After much reflection it appears proper to adopt the figure 900,000 as being unquestionably a safe and rather low estimate, and we shall accordingly use this as our basis in computing and comparing all ratios of sickness, mortality, &c. There are, however, two sources of difficulty met with in attempting to give any definite idea of the health of Philadelphia during this particular period. The first of these is incidental to all such calculations, and depends upon the fact that the records of the Board of Health give only the number of cases of death from various causes, and that no means exist for obtaining the actual number of cases of such sickness which have occurred. In regard to dangerous affections, where the rate of mortality is considerable and more or less definite, it is possible to make an approximative calculation of the total number of cases which have occurred, based upon the number of deaths. But in the case of comparatively non-fatal affections, it is obviously impossible to apply any such rule. The other source of difficulty lies in the fact that much of the sickness

which occurred was among visitors, who in many instances, as soon as attacked, returned to their homes. It is of course impossible to estimate what amount of mortality may have thus occurred in different parts of the country from sickness actually contracted in Philadelphia. So much discussion of this question has taken place in many quarters, both at the time and since the close of the Exhibition, and so many statements were made which we are compelled to regard as greatly exaggerated, that it seems necessary to consider it somewhat in detail. It cannot be doubted that, owing to the unusually severe character of the season, and perhaps to peculiar atmospheric conditions which we cannot appreciate, there existed a strong tendency to diarrhœal and typhoid affections over a large section of the country. During the six months with which we are chiefly concerned the above diseases are the only ones which caused any considerable amount of mortality, and we shall therefore devote particular care to their consideration. In speaking of the sickness among the visitors to the Exhibition, we have already alluded to the numerous causes which predisposed them to diarrhœal and febrile affections. We beg here to refer to what was said at that point, because we are convinced, from careful observation and reflection, that there existed no special conditions in the city, either at the Exhibition grounds or elsewhere, whether in the form of imperfect drainage, impure drinking-water, or any other special local feature, which were calculated to induce sickness. We have endeavoured to show that, on the contrary, the great proportion of sickness which did occur among the visitors to the Exhibition was dependent upon the circumstances of their visit, such as long and hurried journeys, excessive fatigue while at the grounds, indiscretions in eating and drinking, &c.

Not only indeed did large numbers of persons arrive in the city thus predisposed to contract sickness from any cause, but we became acquainted with the fact that in many cases sickness was actually contracted and had even developed itself before their arrival here. It is of course impossible to estimate the number of such cases, but from our personal knowledge of several deaths and of not a few cases of serious sickness, occurring in this manner, we infer that the total must have been large. Indeed, when we consider the full force of these influences, and the vast numbers upon whom they operated, it appears remarkable that the mortality statistics were not more seriously affected than they were. Thus, we find that out of 10,294 deaths in Philadelphia from all causes during the six months from May 10 to November 10, only 1,333, or 11·8 per cent., were from diarrhœal affections. Of this number no less than 1,232 deaths occurred among children under 5 years of age, leaving only 101 deaths from all diarrhœal affections during the entire Exhibition period among adults and children above 5 years of age.

In comparing this with the mortality from the same causes during the corresponding period of previous years, it is found that it is even below the average. Thus, while during the hot months of 1876, from May to November inclusive, the mortality from diarrhœal affections among children under 5 years of age was 1·38 per 1,000 of the total living population, during the 7 years from 1862 to 1868 inclusive the rate was 1·78 per 1,000. In regard to diarrhœal affections occurring among adults, the record of 1876 shows no less favourable results in comparison with previous years. How entirely these diseases were under the influence of high temperature is evident from the fact that, after the temperature had continued above 70° for a short time, the mortality from diarrhœal affections began to increase; and that, from the close of June, when the mean weekly temperature reached 80°, it continued to increase with frightful rapidity for 3 weeks, when a decrease in temperature was accompanied by a fall in the mortality; and finally that, during the last week of July and the first week of August, when the mean temperature was 71° and 70°, this fall continued at a rapid rate. A rise in weekly temperature to 78° and 76°, during the middle of August, was accompanied with a moderate rise in the mortality from diarrhœal affections, quickly followed, however, by a still more decided and persistent fall, so that after the first of September the number of deaths from that cause was comparatively small. It has already been shown that scarcely any part of this mortality was connected with the influx of visitors to the city; and this is further proved by the fact that from the very time, September 1, when the mortality rapidly and finally fell, the attendance at

the Exhibition grounds rapidly and steadily rose. The number of cases of diarrhœal affections treated at the Medical Department, and due exclusively to such causes as indiscretions in eating and drinking, followed with considerable closeness the fluctuations in the weekly attendance at the Exhibition. As corroborating the truth of what has more than once been stated with regard to the sanitary advantages of Philadelphia, we ask attention to the following table, which shows the relative mortality from diarrhœal affections during 1876 in Philadelphia and some other large American cities :

1876.	Philadelphia.	New York.	Brooklyn.	Baltimore.	Chicago.
Population - -	825,594	1,054,000	506,233	355,000	420,000
Mortality from diarrhœal affections -	1,417	3,782	1,542	866	954
Death-rate from diarrhœal affections per 1,000 living -	1·66	3·50	3·04	2·44	2·28

Next to diarrhœal affections, which caused a mortality of 1,333 out of 2,485 deaths from all zymotic diseases during the Exhibition period, typhoid fever was more fatal than any other disease of this class. No less than 450 deaths are recorded as having occurred during the six months from this affection; and taking the entire year 1876, the total number of deaths from this cause was 761.

We have already expressed our belief that in a not inconsiderable portion of these cases, inflammatory diarrhœas of typhoid type were reported as cases of true typhoid fever. But this does not interfere with the fact that during the entire year 1876 there was a much larger amount of typhoid fever in this city than is usual. In order to clearly show this it is only necessary to give the following table of the annual mortality from typhoid fever for the past 16 years, with the annual death-rate per 1,000 living :

Year - -	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876
Population in thousands - -	565	565	565	565	565	674	674	674	674	674	674	725	750	775	800	825
Total mortality from typhoid fever -	281	654	486	648	773	381	367	395	373	409	313	369	382	472	420	760
Annual death-rate per 1,000 living -	·49	1·15	·85	1·14	1·36	·56	·54	·58	·55	·60	·47	·50	·50	·60	·52	·91

During the Exhibition period the population may be estimated at 900,000, and this, with a mortality during those six months of 450 from typhoid fever, gives a rate of annual mortality from this cause of 1 per 1,000. If will be seen, on examining this table, that the annual death-rate per 1,000 from typhoid fever during last year was exceeded during the years 1862, 1864, and 1865, while it was very closely approached in 1863. In considering the causes which led to the high rate of mortality from this disease during the latter years, it will be found that it was connected with the large number of soldiers who were quartered in and around the city. So, too, in considering the sudden increase in typhoid fever that occurred during the year 1876, the most important cause which suggests itself is the enormous influx of unacclimated visitors during the Exhibition period. It has long been known, in connection with typhoid fever, that none are so likely to be attacked as the residents of small towns or rural districts, when visiting large cities to whose climate and conditions of life they are unaccustomed. This is undoubtedly because such persons are much more susceptible than the permanent residents to the causes of typhoid fever, even though existing only in the moderate degree which is too often found in large cities. The truth of this may be realised from the fact that during the Exhibition period in 1876 the number of deaths from typhoid fever was 450, as contrasted with 207 deaths from this cause during the corresponding period of 1875.

That this increase was due to the vast influx of unacclimated visitors, and not to any special prevalence of the causes of typhoid fever during that period, may be inferred from the fact that in those hospitals which received almost exclusively patients from among the poorer classes resident in the city, the number of cases of typhoid and typho-malarial fevers treated between May 1 and November 15, 1875, was 49, while during the corresponding months of 1876 the number was only 28. On the other hand, in those hospitals which receive patients chiefly of a better class, and to which, consequently, strangers who may be taken sick while on a visit to the city are frequently admitted, the number of cases of typhoid and typho-malarial fevers treated during the Exhibition period of 1876 was about double that treated during the corresponding period of 1875.

Still more convincing evidence in favour of this view is to be found in an examination of the relation borne by the number of deaths from typhoid fever to the number of visitors to the Exhibition grounds. There was no marked increase beyond the ordinary mortality from this affection from May 1 to the last week of July, during which time the number of visitors in attendance at the Exhibition was low. (See the tabulated statement at foot of page.)

During this time, also, the number of strangers arriving in the city was especially small, the attendance at the Exhibition being chiefly of the residents of Philadelphia. The large number of visitors attracted to the city by the ceremonies of the 4th of July, remained for so brief a time that they exerted no influence upon the mortality from this cause. After the week ending July 29, a steady rise in the weekly attendance occurred, which continued to progressively increase, with occasional fluctuations due to special causes, until the close of the Exhibition. With this there was noticed a rise in the weekly mortality from typhoid fever, which continued until the weeks ending August 26 and September 2, when, with a weekly attendance of 347,082 and 321,997 respectively, the mortality from typhoid fever was 31 and 29. After the latter date, although there is a still further marked increase in the weekly attendance at the grounds, the deaths from fever never exceeded the figures above given; but, on the contrary, after October 10 there was a very marked

Week ending	Mortality from Typhoid Fever in Philadelphia.	Admission of Visitors to the Exhibition.	Attendance at the Centennial Hospital.
May 13	7	235,251½	14
„ 20	10	115,236	19
„ 27	12	155,724	51
June 3	10	204,704½	62
„ 10	10	233,406	69
„ 17	12	216,536	117
„ 24	12	232,535	159
July 1	10	210,108	204
„ 8	9	315,853	301
„ 15	10	174,792½	301
„ 22	13	166,744	252
„ 29	18	185,464½	259
August 5	22	196,277	205
„ 12	23	210,075	282
„ 19	26	241,078	276
„ 26	31	347,082	334
September 2	29	321,997	348
„ 9	24	446,032	347
„ 16	12	495,694	359
„ 23	31	624,372	359
„ 30	15	758,160	349
October 7	29	551,669	398
„ 14	21	584,011	307
„ 21	10	700,600	322
„ 28	13	641,021	336
November 4	15	628,348	322
„ 10	16	596,102	211

reduction in the weekly mortality from this cause. The marked effect of the intense heat upon the mortality from diarrhœal affections, not only in Philadelphia but elsewhere, has already been shown; and it is interesting to observe that no similar effect was produced upon the mortality from febrile diseases.

The amount of typhoid fever in neighbouring cities during the Exhibition period was not more than usual during the corresponding months of other years, and this fact is interesting when we bear in mind the statements which were widely circulated at the time, that very numerous cases of typhoid fever occurred among persons who had returned home from their visit to the Exhibition. It is difficult to conceive how this could have been so to any extent without influencing perceptibly the mortality from the febrile affections during that period. It may therefore be stated, in conclusion, that during the six months of 1876, from May 10 to November 10, there occurred in Philadelphia an unusual number of deaths from typhoid fever; that this excess over the usual mortality amounted to about 200 deaths; that the occurrence of this unusual mortality from typhoid fever was not due to the existence of any special cause of that disease in connection with the Exhibition, or to the prevalence in an unusual degree throughout the city at large of its ordinary causes; but that it was due to the enormous influx of unacclimated visitors, who were rendered additionally liable to the action of morbid influences of every kind by their mode of life while in this city.

Having thus spoken of the statistics of typhoid fever during 1876, both in this city and elsewhere, a few words only upon its character are called for in this report. It will have been observed that the terms typhoid and typho-malarial fever have been used. The first of these is employed, as is well known, to designate a specific febrile affection, characterised by a peculiar form of ulceration of the intestines, and caused, so far as is yet known, by the emanations from decomposing animal matter, and especially by those from the evacuations of patients having this same disease. The term typho-malarial fever has been introduced of late years to designate a disease in which it is believed the specific poison of typhoid fever exists, complicated with malarial poison. Medical opinion is still somewhat divided with regard to the latter affection, although it is generally acknowledged that such a disease, due to the combined action of the two poisons, does actually exist. It seems probable, however, that the term typho-malarial fever has often been used inaccurately, so as to include cases of irregular typhoid fever, and probably also cases of simple intestinal catarrh with marked typhoid prostration and irregular febrile action.

We believe that the typhoid fever which occurred during 1876 was not much modified, at least here and in neighbouring localities, by the admixture of a malarial element. This opinion is based not only on the characters of the disease as it came under our notice, but also on the small amount of malarial fever of any form which occurred here during that season. It is true that, in a considerable number of instances, the cases were termed typho-malarial fever in the returns to the Board of Health, but we are convinced that the large majority of such cases were either uncomplicated typhoid fever of irregular or abortive type, or else catarrhal diarrhœa with marked typhoid prostration of system. Indeed we have more than once expressed our belief that a considerable proportion of the deaths recorded as from typhoid fever were in reality due to this latter condition. The typhoid fever itself was very irregular. In many cases it ran a much shorter course than in the usual typical form, not exceeding 15 to 18 days. Another marked peculiarity was the frequent occurrence of hæmorrhage from the bowels, which took place in a larger proportion of cases than usual.

It is, of course, difficult to estimate the ratio of mortality of a disease occurring under such circumstances, but from the data in our possession it may be stated as about 18 per cent. As an illustration of the extent to which typhoid fever is influenced both in its degree of prevalence as well as in its mortality by epidemic causes, which it is difficult to appreciate, it may be stated that in Paris (where the mortality during the previous three years was as follows: in 1873, 1,007; in 1874, 846; in 1875, 1,001) the number of deaths from this disease during the year 1876 amounted to 2,073, and so severe was

the type that the rate of mortality rose as high as 35 per cent. of all cases treated.

We have entered thus at length into the discussion of the typhoid fever of 1876 on account of the large amount of public interest which this disease attracted during the Exhibition period. In summing up our remarks upon the sanitary condition of Philadelphia during this interesting time, it may be stated that the general results do not differ materially from those given by us in the latter part of September.

At that time the data in our possession did not enable us to distinguish between the different classes of diseases with as much accuracy as we have done in the following table, which embraces the entire Exhibition period:

—	Population in thousands.	Total mortality from all causes.	Annual death-rate per 1,000 living.	Total mortality from all Zymotic Diseases.*	Annual death-rate per 1,000 from Zymotic Diseases.	Total mortality from Typhoid Fever.	Annual death-rate per 1,000 from Typhoid Fever.	Total mortality from diarrhœal affections.	Annual death-rate per 1,000 from diarrhœal affections.
London - -	3,489	37,592	21·54	6,905	3·99	606	·34	3,149	1·80
Philadelphia -	900	10,294	22·77	2,485	5·5	450	1	1,333	2·96
Baltimore -	350	4,020	22·97	1,524	9·2	148	·84	652	3·72
Chicago - -	420	4,927	23·46	2,277	10·8	108	·51	918	4·37
Boston - -	342	4,144	24·33	1,422	8·3	98	·56	772	4·5
Brooklyn -	506	6,453	25·49	2,583	10	53	·20	1,485	5·86
Paris - -	1,851	23,735	25·63	—	—	1,122	1·21	—	—
New York -	1,054	15,492	29·40	5,884	11	168	·30	3,527	6·69
Berlin - -	980	16,407	33·86	—	—	393	·81	—	—

It will be seen from this that of the nine large cities from which we have been able to secure returns, Philadelphia was second to London alone in point of average total mortality. It will also be seen that while the annual death-rate from typhoid fever per 1,000 living in Philadelphia was higher than in any other of these cities, excepting Paris, the annual death-rate per 1,000 from all zymotic diseases, which include diarrhœal affections, continued and eruptive fevers, &c., was relatively smaller in this city than in any other save London. This result is chiefly due to the relatively small mortality from diarrhœal affections, which gave an annual death-rate per 1,000 of only 2·96, as contrasted with 6·69 in New York, or 5·86 in Brooklyn.

If we have been correct in our conclusions previously stated, it may therefore be confidently asserted that Philadelphia has again vindicated her claim to be regarded as the most healthy city in the world, with a population of over 500,000, with the single exception of London.

It is proper to state that in the establishment of the hospital a full supply of medicines was presented, with great liberality, by the following well-known firms: Messrs. Powers and Weightman, Rosengarten and Sons, Hance, Brothers, and White, and Bullock and Crenshaw, all of Philadelphia.

* By zymotic diseases are to be understood all diarrhœal affections; eruptive fevers, such as small-pox, measles, scarlatina, &c.; typhoid and malarial fevers; diphtheria, &c.

Thanks of the Canadian Government

FOR

General Assistance rendered by the British Commission, and for special Services of the British Members of the International Jury in the Assignment of Awards granted by the Government of the Dominion to Canadian Exhibitors.

Sir, Downing Street, 14th December 1877.

I am directed by the Earl of Carnarvon to request that you will lay before the Duke of Richmond and Gordon the accompanying copy of a Despatch from the Governor-General, enclosing a Minute of his Privy Council, requesting that the thanks of the Government of Canada may be given to yourself for your valuable assistance to the Canadian Commisssion at the Philadelphia Exhibition, and to the gentlemen who were kind enough to act as Judges in the award of medals given by the Dominion Government to Canadian exhibitors.

2. I am to add that this communication has afforded much satisfaction to Lord Carnarvon, as showing the high sense which the Canadian Government entertain of the services rendered by yourself, and by those who acted as Judges.

I am, &c.

(Signed) Robert G. W. Herbert.

Colonel Sir H. Sandford.

The Earl of Dufferin to the Earl of Carnarvon.

CANADA.

No. 230.

My Lord, Government House, Ottawa, November 21st, 1877.

I have the honour to transmit herewith to your Lordship a copy of a Minute of the Canadian Privy Council requesting that the thanks of this Government may be given to Colonel Sir H. Sandford for his valuable assistance to the Canadian Commission at the Philadelphia Exhibition, and to the gentlemen who were kind enough to act as Judges in the award of medals given by the Dominion Government to Canadian exhibitors.

I have, &c.

The Right Honourable (Signed) Dufferin.
The Earl of Carnarvon,
&c. &c. &c.

Copy of a Report of a Committee of the Honourable the Privy Council approved by His Excellency the Governor General on the 17th November 1877.

The Committee of Council have had under consideration the Report of the Canadian Commissioners at the International Exhibition at Philadelphia, wherein reference is made to the services rendered by the Judges who awarded the Medals given by the Dominion Government to Canadian Exhibitors. These services were gratuitously rendered, at the sacrifice of much time and

labour, and enabled the Canadian Commission to successfully carry out the distribution of prizes among the Canadian Exhibitors.

The Committee recommend that the thanks of the Government of Canada be given to those gentlemen who acted as Judges on that occasion, for the readiness with which they undertook the arduous duty, and for the discriminating care, efficiency, and discernment evinced in the awarding of the prizes.

The Committee suggest that Colonel Sir H. B. Sandford, R.A., the British Commissioner, be requested to convey to the British Judges the assurance that their services were fully appreciated by the Government of Canada and the Canadian Exhibitors.

The Committee also recommend that the thanks of the Government of Canada be given to Colonel Sir H. B. Sandford for the valuable services rendered to the Canadian Commission, and that Your Excellency will be pleased to communicate the same to Colonel Sandford.

Certified,

(Signed) H. A. Henisworth,
C.P.C.

List of Judges who awarded the Prizes given by the Dominion Government to Canadian Exhibitors at the International Exhibition at Philadelphia, and the Classes for which they adjudicated.

1. Machinery of all kinds:
   Judges.—Dr. Anderson, C.E., Mr. Hulse, C.E., Mr. Henry Mitchell, Captain Douglas Galton, C.B., D.C.L., F.R.S., Mr. Barlow, C.E., Mr. Paget, C.E.
2. Agricultural Machinery and Implements:
   Judge.—Mr. John Coleman.
3. The Fine Arts:
   Judges.—Mr. C. W. Cope, R.A., Mr. Peter Graham, Mr. R. H. Soden Smith, M.A.
4. Manufactures from Metals:
   Judges.—Hon. Sir J. Bain, Dr. Anderson, C.E., Mr. David MacHardy, J.P.
5. Wool, Raw, Articles of Clothing, &c:
   Judges.—Mr. H. Mitchell, Mr. Isaac Watts, Mr. Hulse, C.E.
6. Leather and its Manufactures:
   Judge.—Mr. Hulse, C.E.
7. Musical Instruments:
   Judge.—Sir Charles Reed, LL.D.
8. Carriages and Furniture:
   Judges.—Col. Rich, R.E., Mr. P. Graham.
9. Grains and Meals, and Manufactures thereof:
   Judges.—Dr. Odling, F.R.S., Mr. John Coleman.
10. Cured Meats, Fish, &c.:
    Judges.—Dr. Odling, F.R.S., Mr. John Coleman.
11. Minerals:
    Judge.—Mr. I. Lowthian Bell, M.P., F.R.S., C.E.
12. Pharmaceutical Preparations, Soaps, &c.
    Judges.—Dr. Odling, F.R.S., Major Noble, R.A.

13. Ladies Department:
Judges.—Col. Rich, R.E., Major Noble, R.A., Capt. Douglas Galton, C.B., D.C.L., F.R.S.

14. Philosophical Instruments:
Judges.—Sir William Thomson, LL.D., D.C.L., F.R.S., Sir Charles Reed, LL.D.

15. All Articles not included in above:
Judge.—Mr. Soden Smith, M.A.

For Horses:
Judge.—Mr. Thomas Parrington.

For Horned Cattle:
Judge.—Mr. Thomas Duckham.

For Sheep:
Judge.—Mr. Owen C. Richards.

For Swine:
Judge.—Mr. G. W. Baker.

For Wines:
Judge.—M. Rebour of France.

For Malt Liquors:
Judge.—Mr. Massey, of Philadelphia.

For Cheese:
Judge.—Mr. Fearman.

For Poultry:
Judge.—Mr. Halstead.

Supplemental Judge.—Mr. Augustus Morris, Commissioner for New South Wales.

LONDON:
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